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(12) **United States Patent**
Ibrahim et al.

(10) **Patent No.: US 8,328,853 B2**
(45) **Date of Patent: Dec. 11, 2012**

(54) **STATIC COMPRESSION DEVICE**

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(73) Assignee: **IB Medical, LLC**, Longmont, CO (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 750 days.

(21) Appl. No.: **12/522,147**

(22) PCT Filed: **Mar. 20, 2007**

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§ 371 (c)(1),
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PCT Pub. Date: **Nov. 8, 2007**

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(51) **Int. Cl.**
A61B 17/66 (2006.01)

(52) **U.S. Cl.** **606/282**; 606/70; 606/71; 606/279; 606/281; 606/286

(58) **Field of Classification Search** 606/61, 606/69, 70, 71, 279–299, 272
See application file for complete search history.

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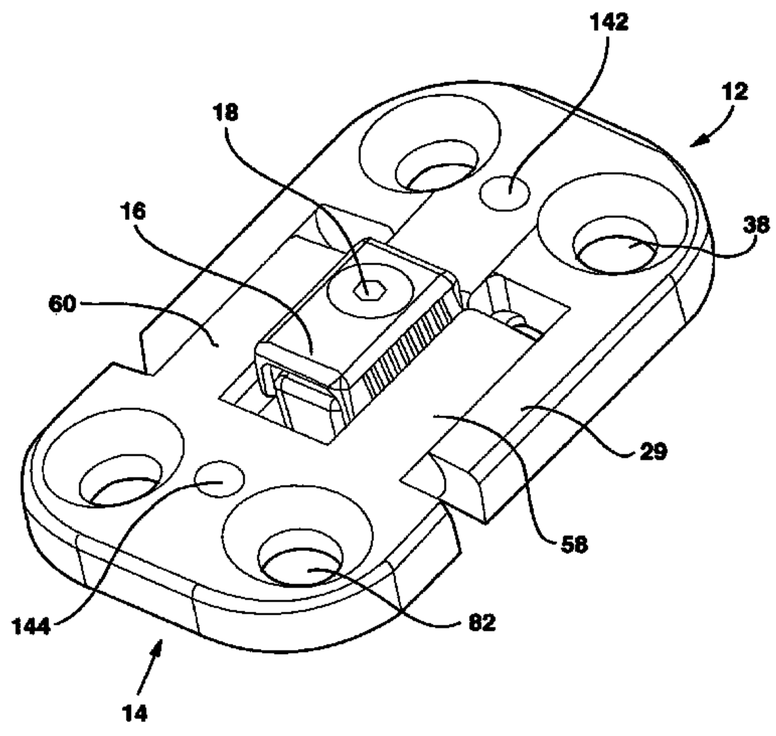
Primary Examiner — Kevin T Truong
Assistant Examiner — Samuel Hanna
(74) *Attorney, Agent, or Firm* — Lathrop & Gage LLP

(57) **ABSTRACT**

A Static Compression Device (SC device) for active, measurable compression of a fusion graft by the surgeon at the time of surgery is disclosed. The SC device is attachable to adjacent vertebral bodies or other pieces of bone and has a device that applies compressive force to the adjacent vertebral bodies or pieces of bone to assist fusion according to Wolffs law. The SC device has a locking mechanism that maintains the compression applied at surgery, but prevents further compression (settling) from occurring after surgery. The SC device allows the surgeon the ability to compress a segment, measure the applied compression, and lock the segment in the compressed position. In one embodiment of the invention, the pressure is applied to the SC device through a compression device that applies a desired and measurable amount of force. In this embodiment, the combination of the SC device with a pressure applying and measuring device allows the surgeon more control over the force applied to a cervical, thoracic or lumbar implant than has previously been available. In the preferred embodiment, the SC device compresses two or more adjacent vertebrae across an adjacent bone graft to facilitate fusion of these vertebrae to treat pain produced by pressure from the disks between such vertebrae bulging and resulting in contact with and pressure on the spinal cord and adjacent nerve roots. In other embodiments, the SC device may be used to apply measurable compression across any type of bony interface (e.g. fractures) to facilitate union.

21 Claims, 50 Drawing Sheets



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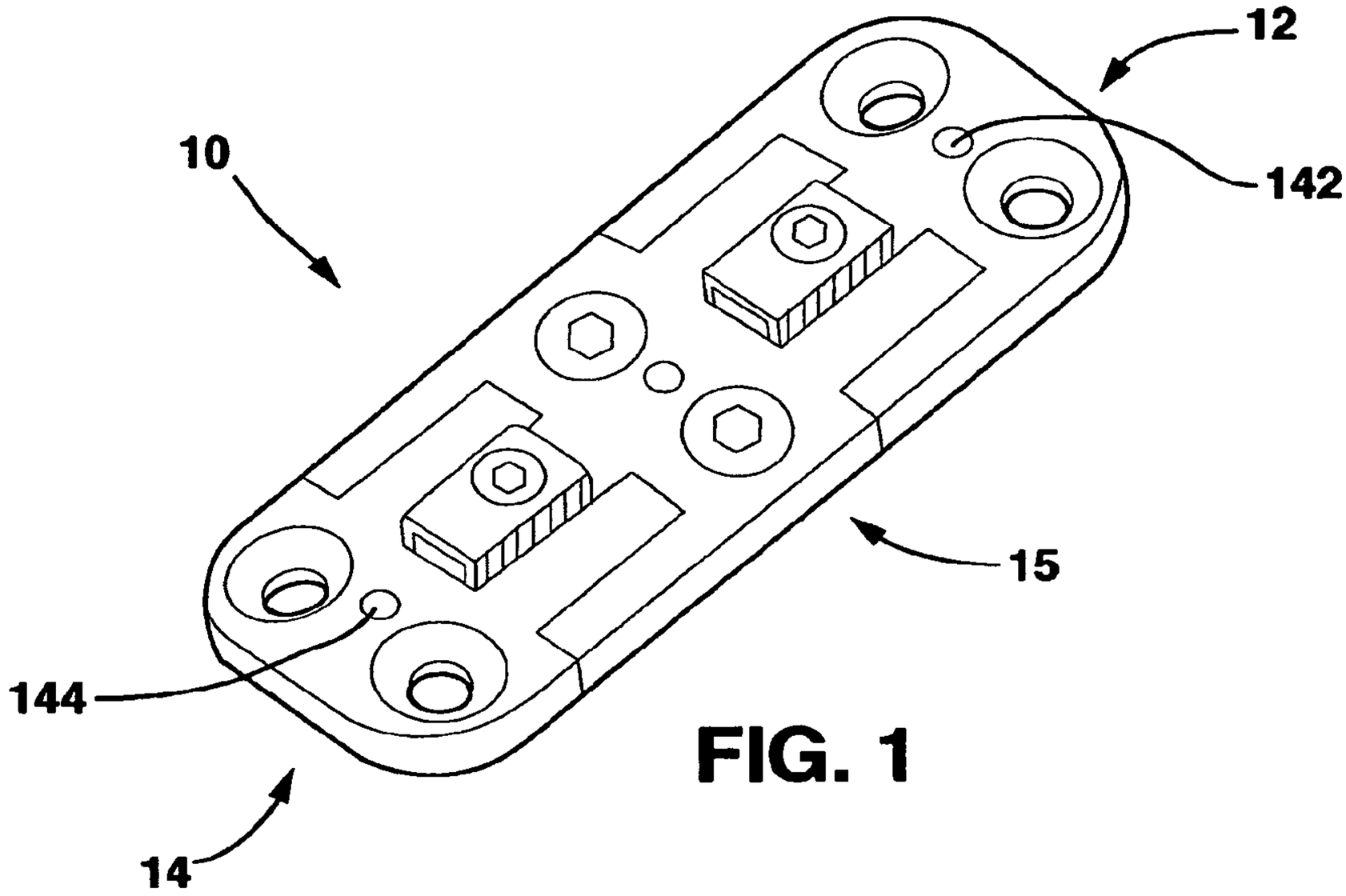
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FIG. 1

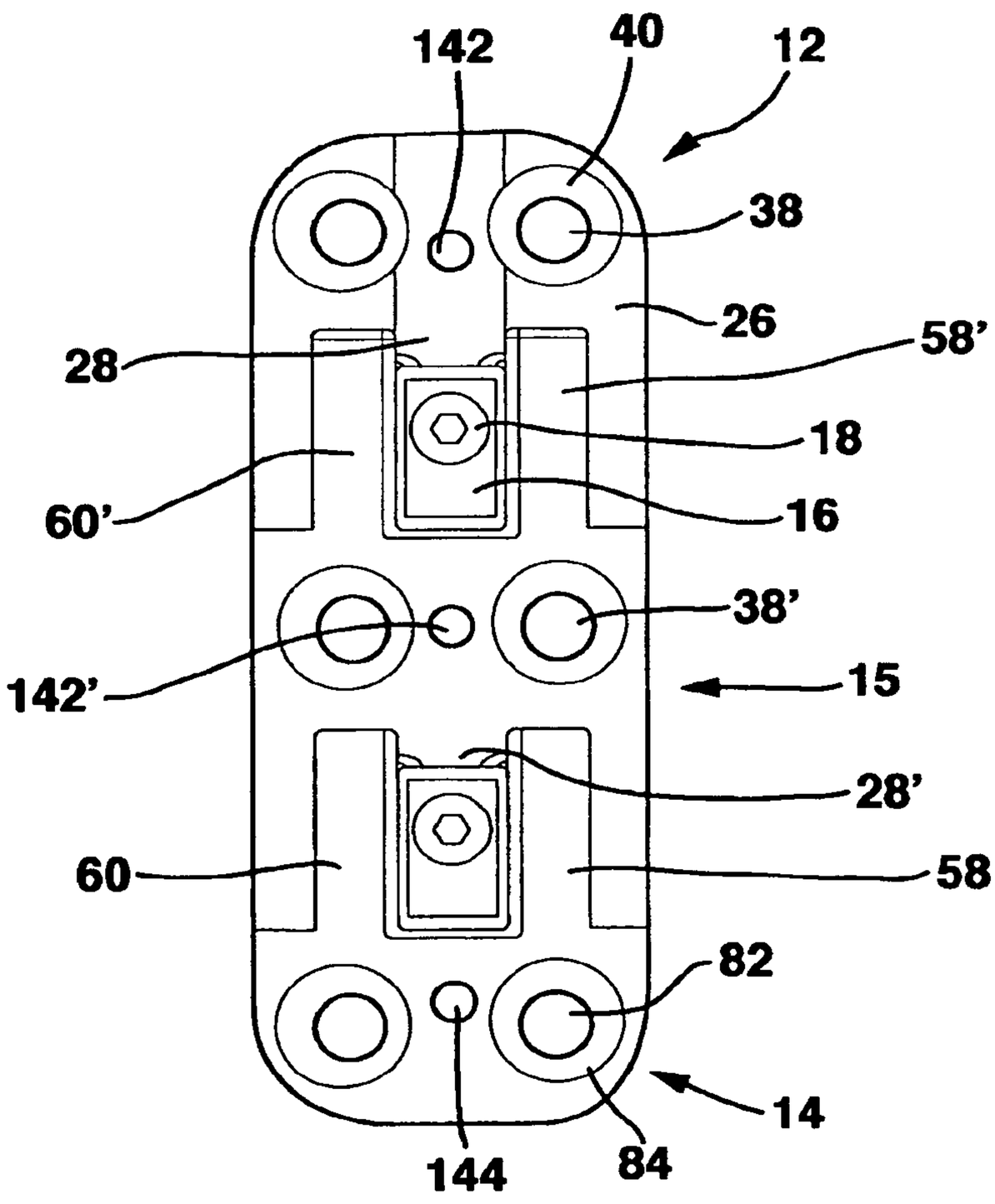
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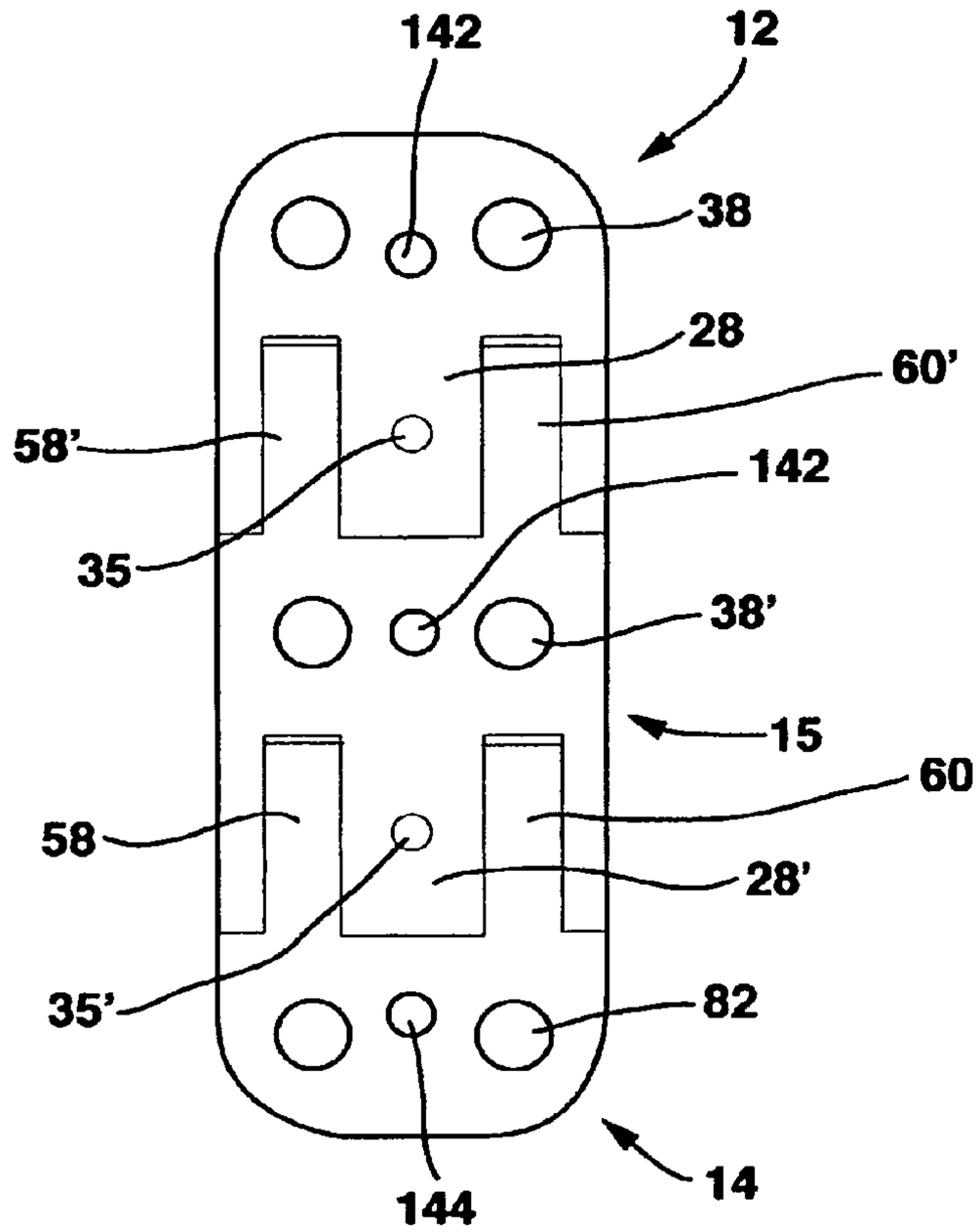
FIG. 2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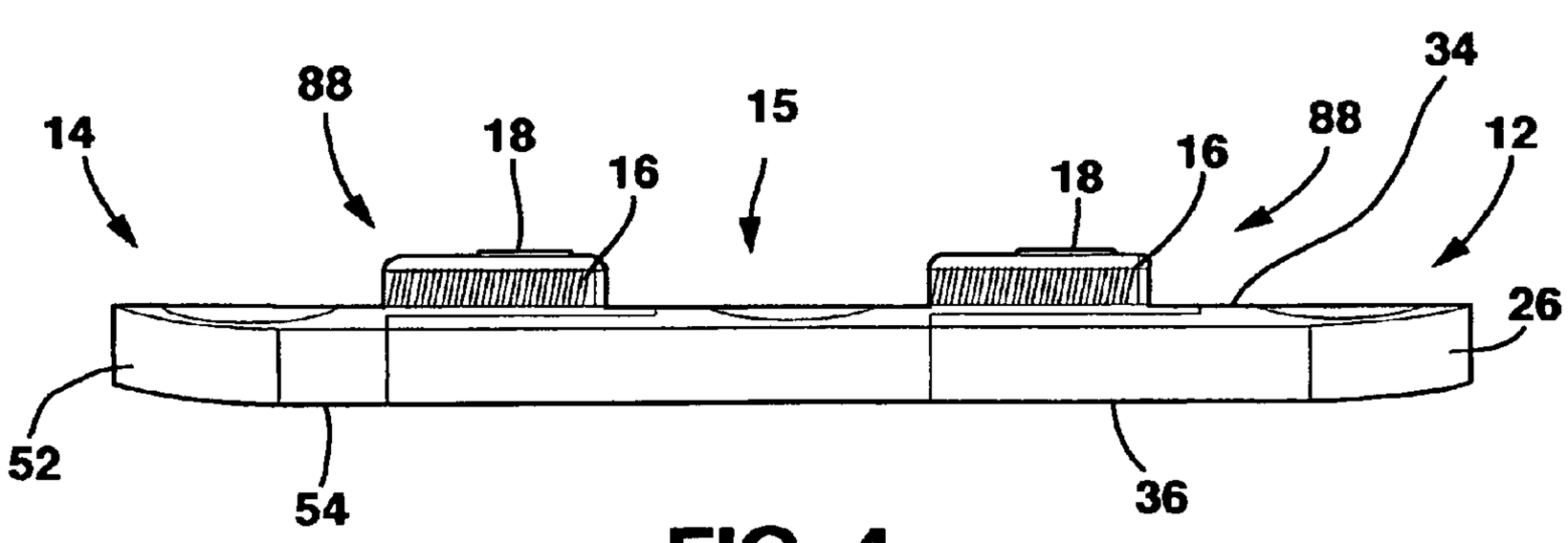
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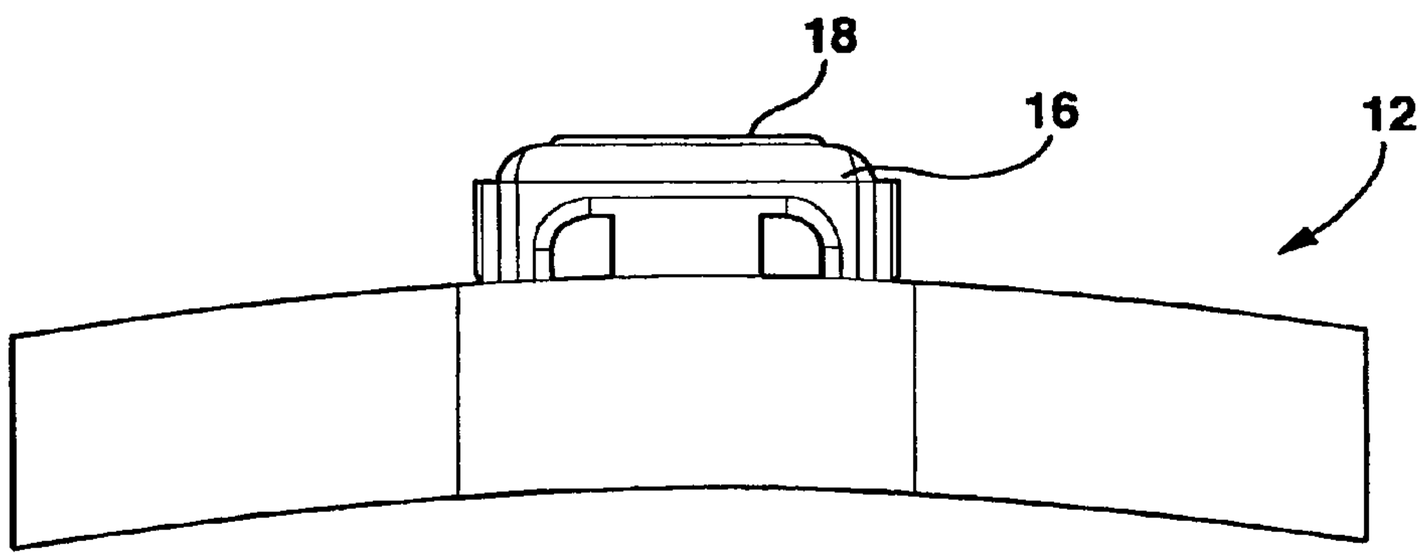

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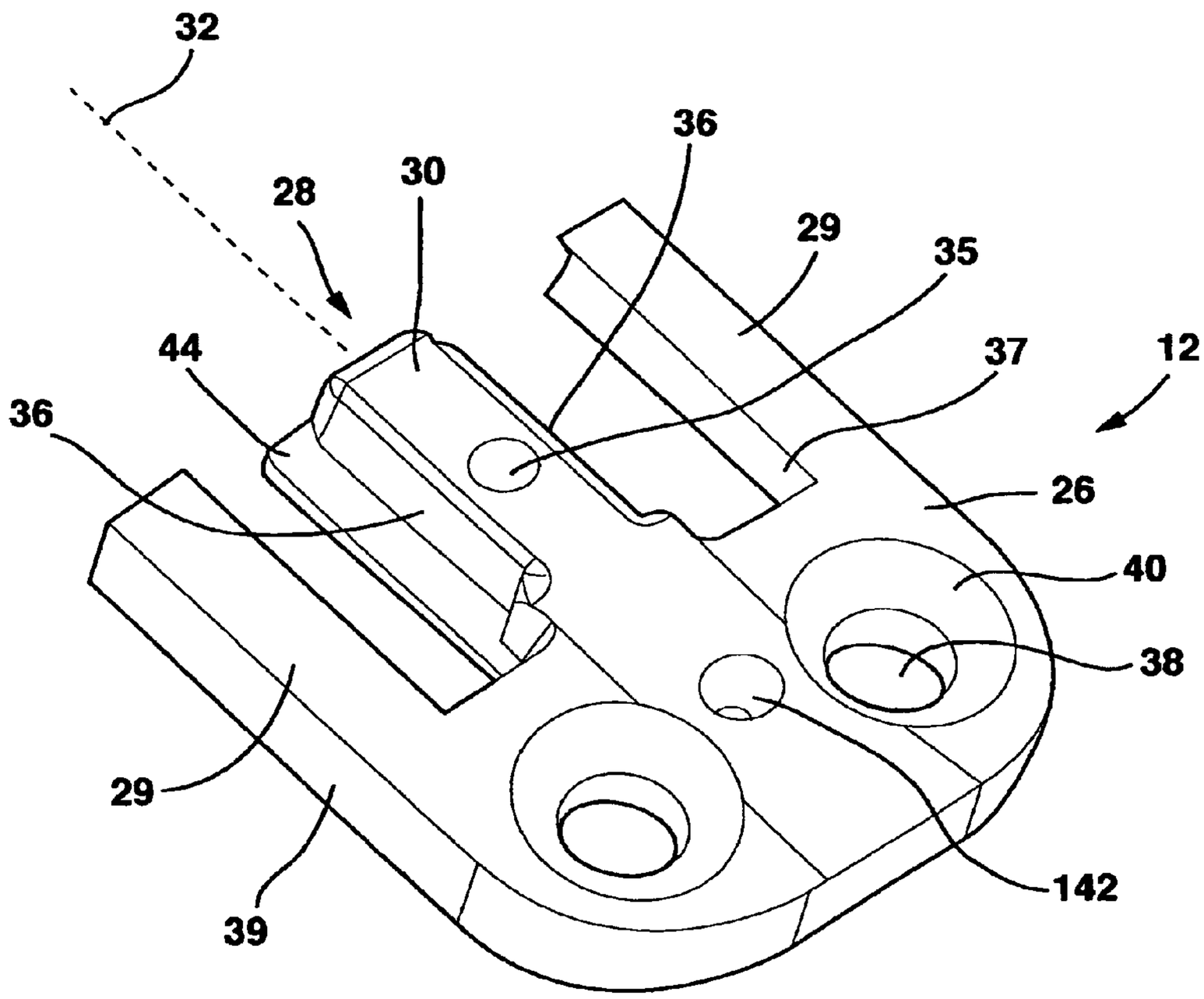

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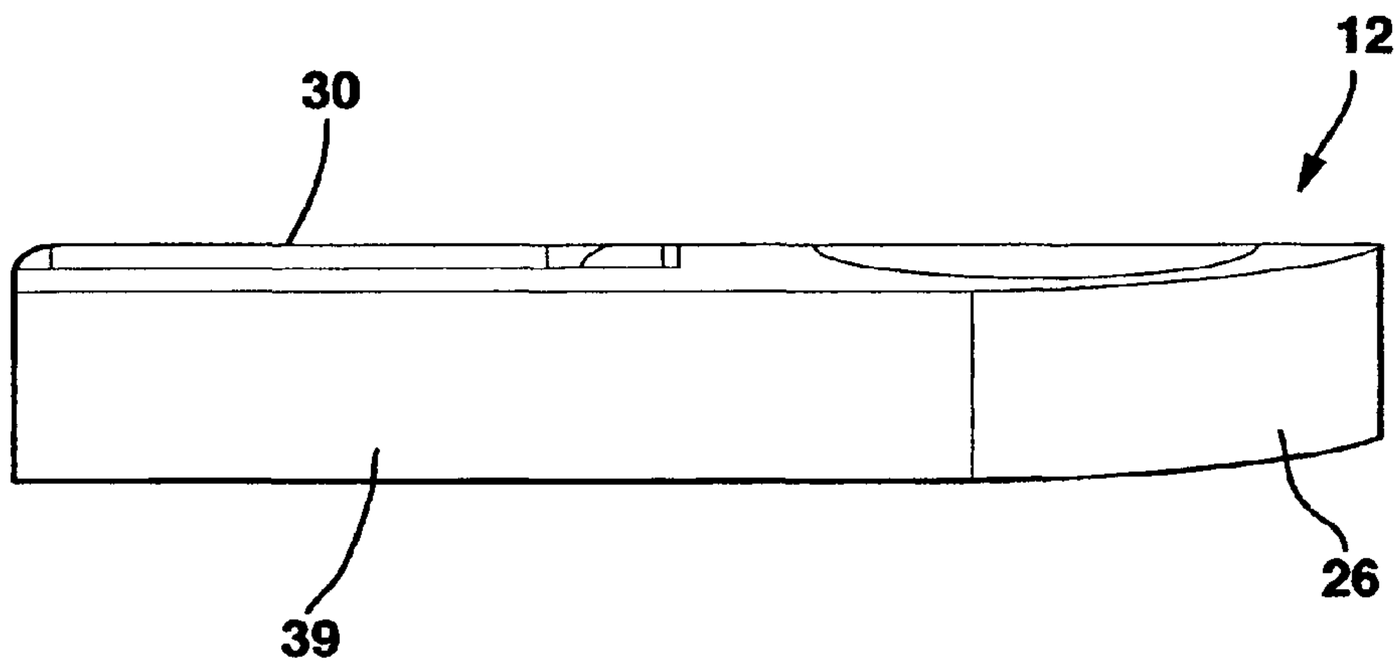

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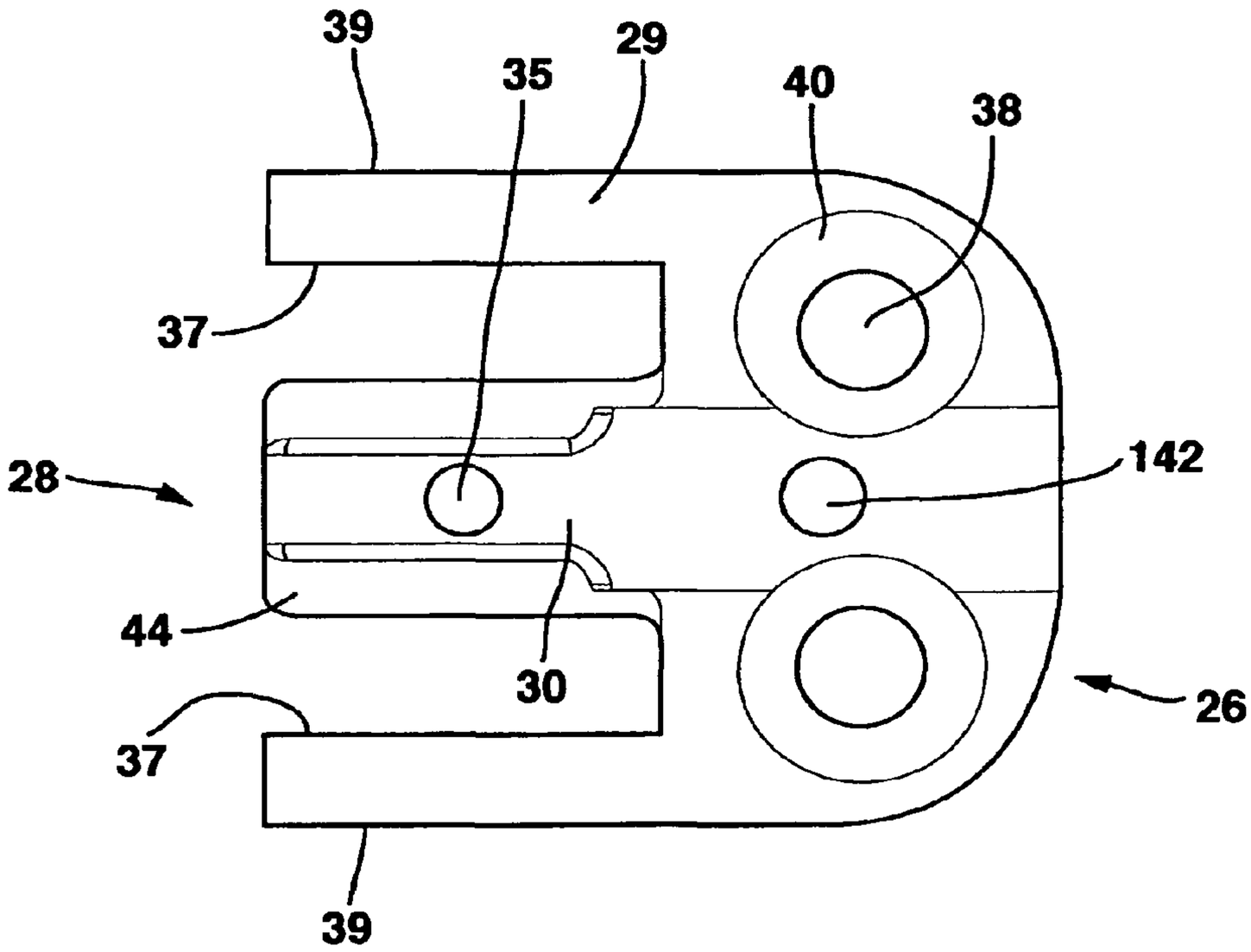

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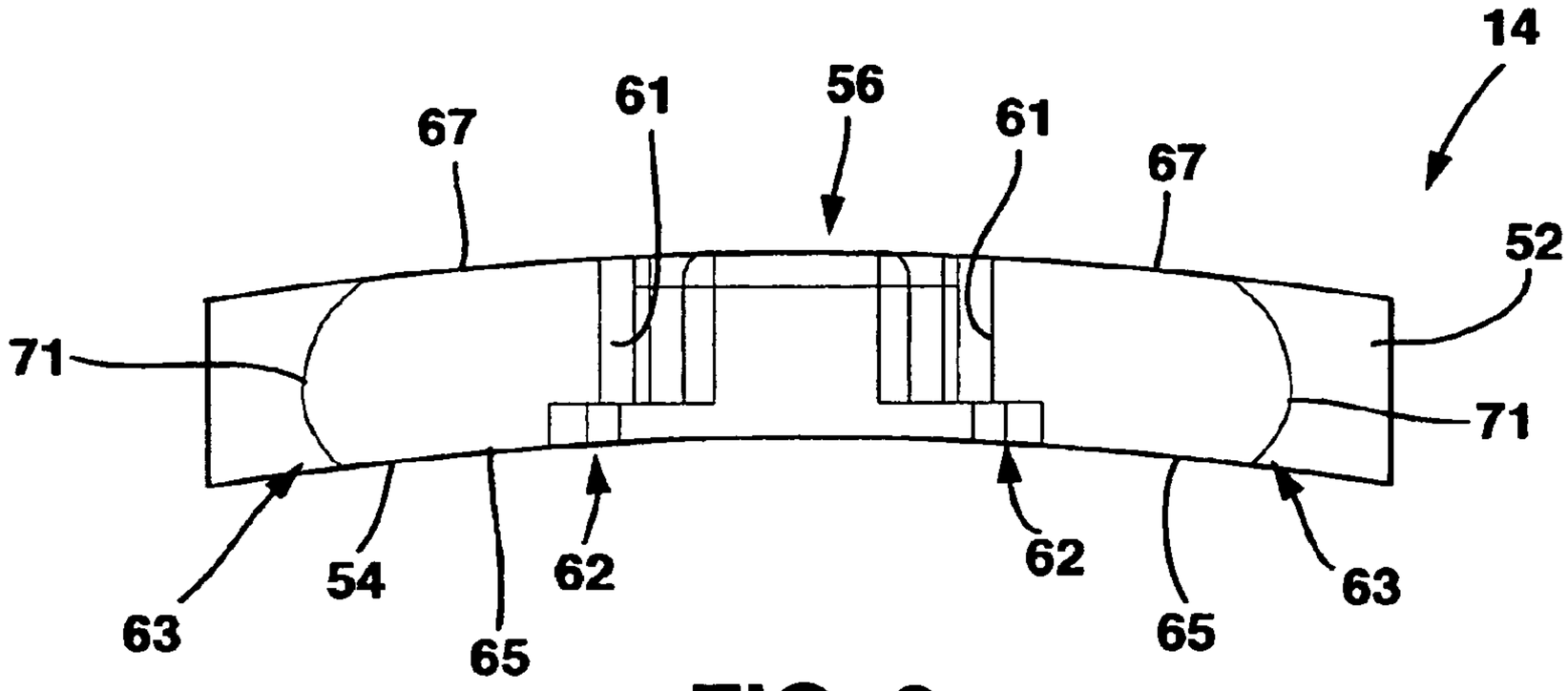
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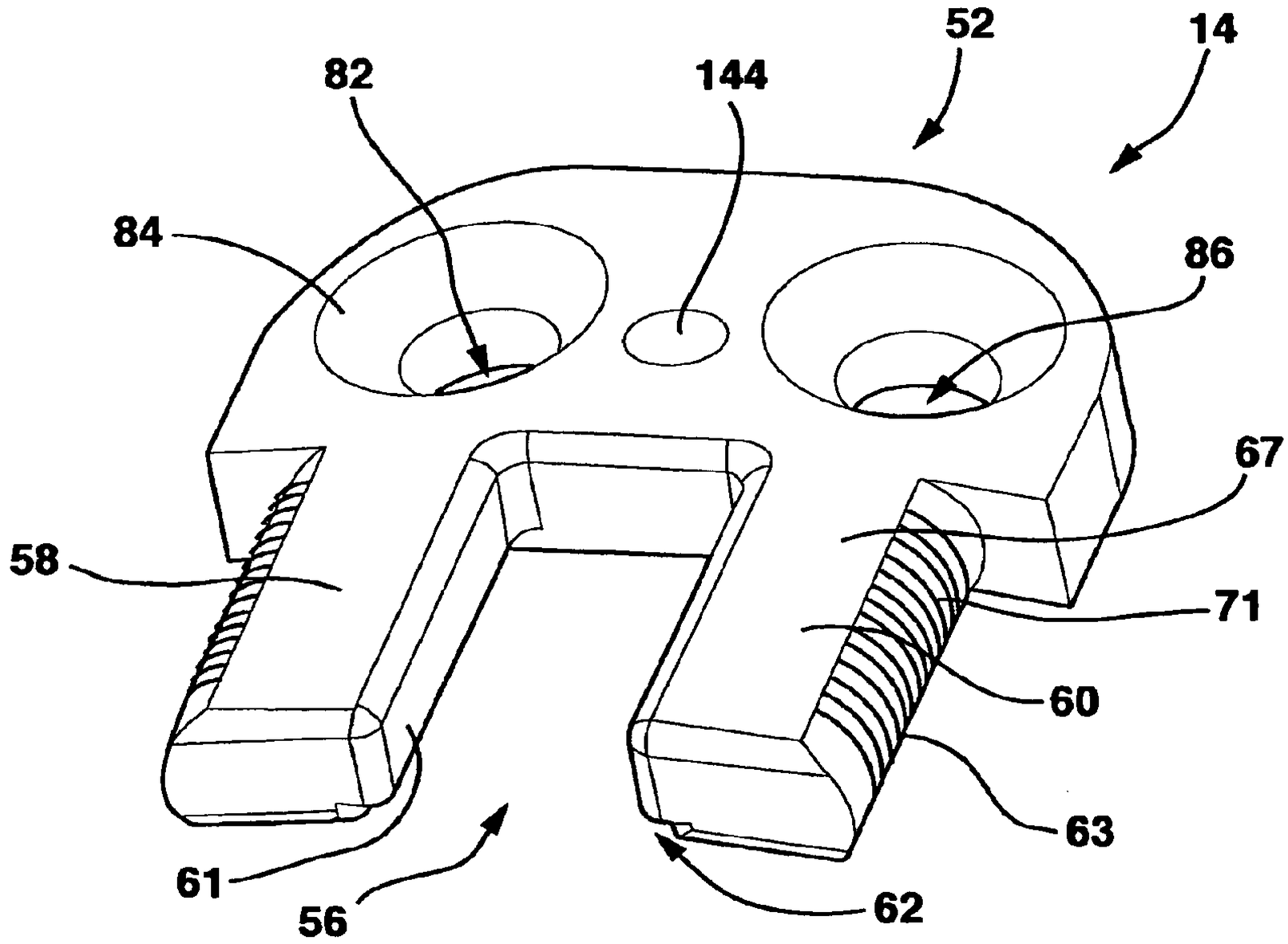
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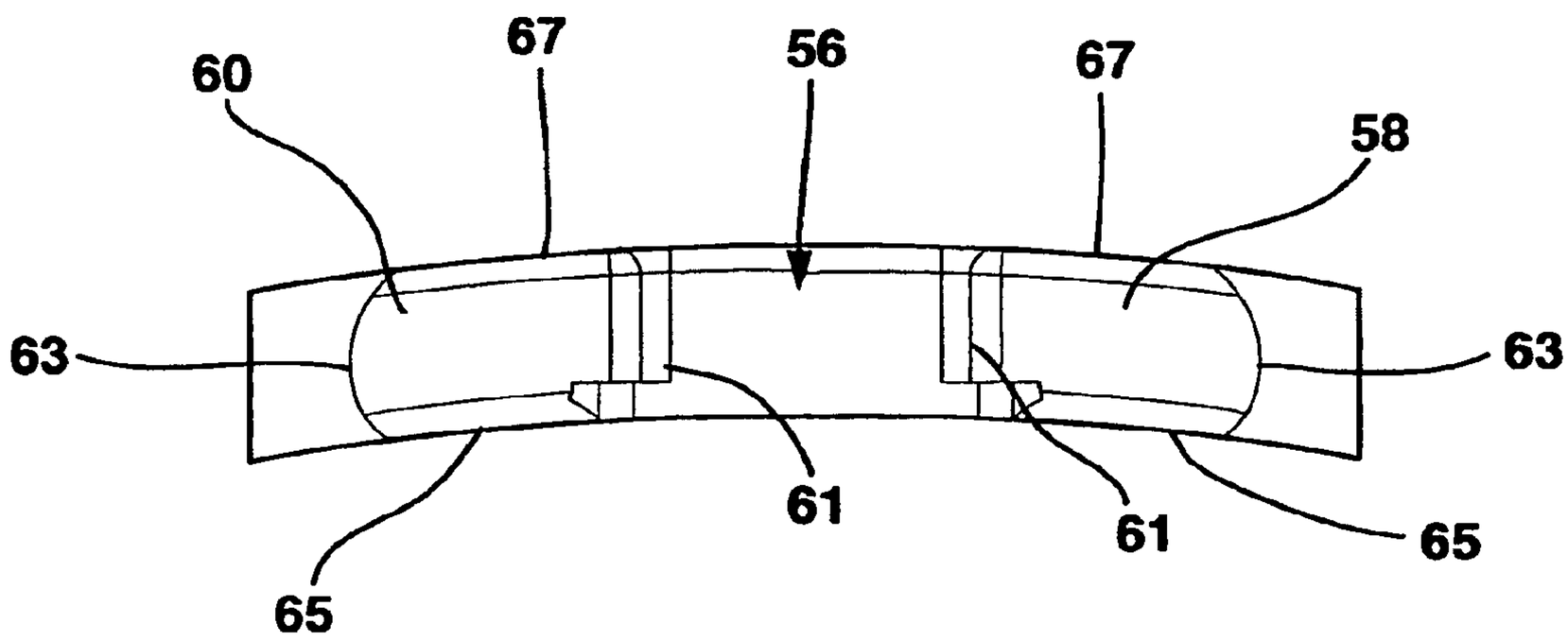

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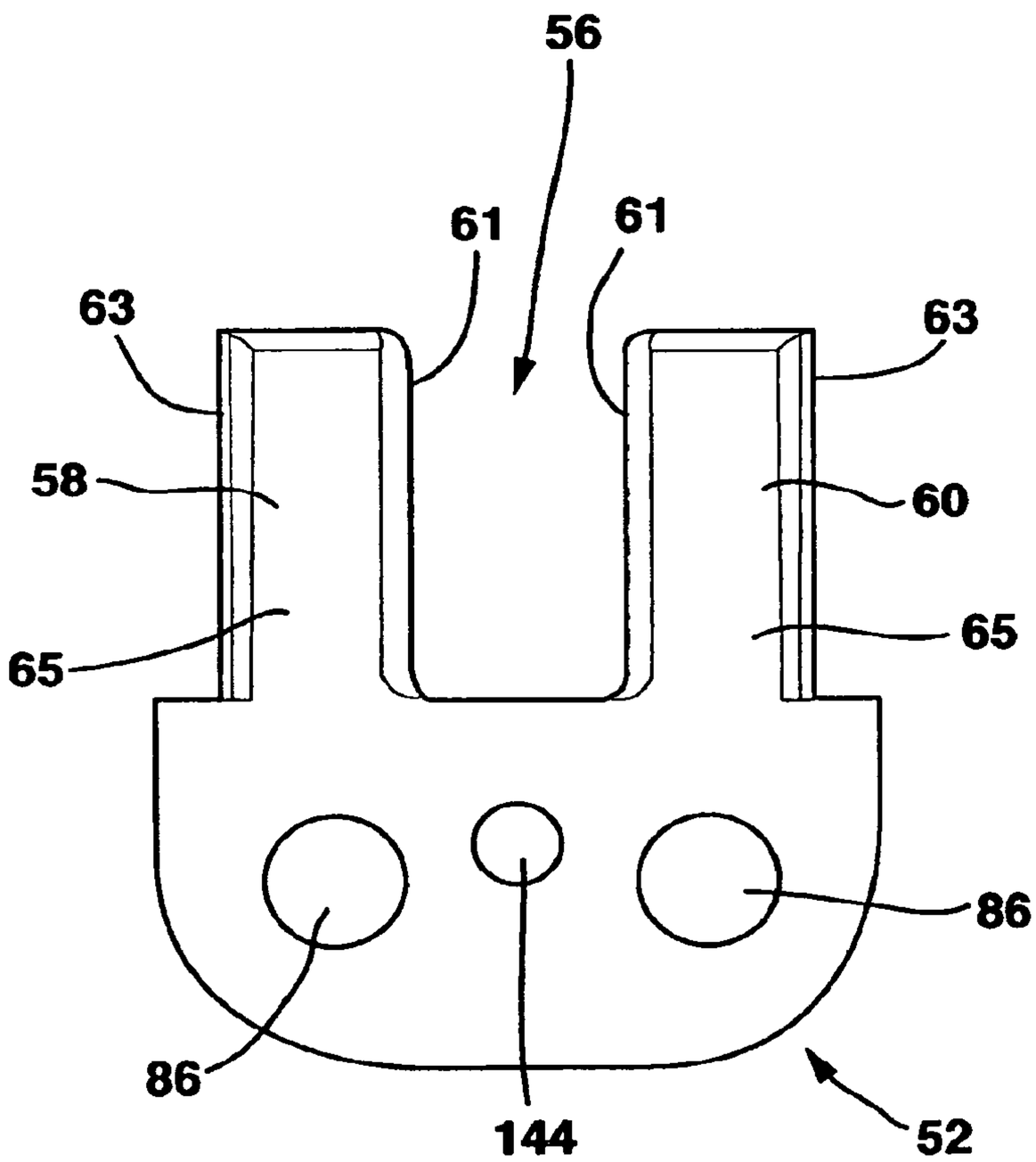

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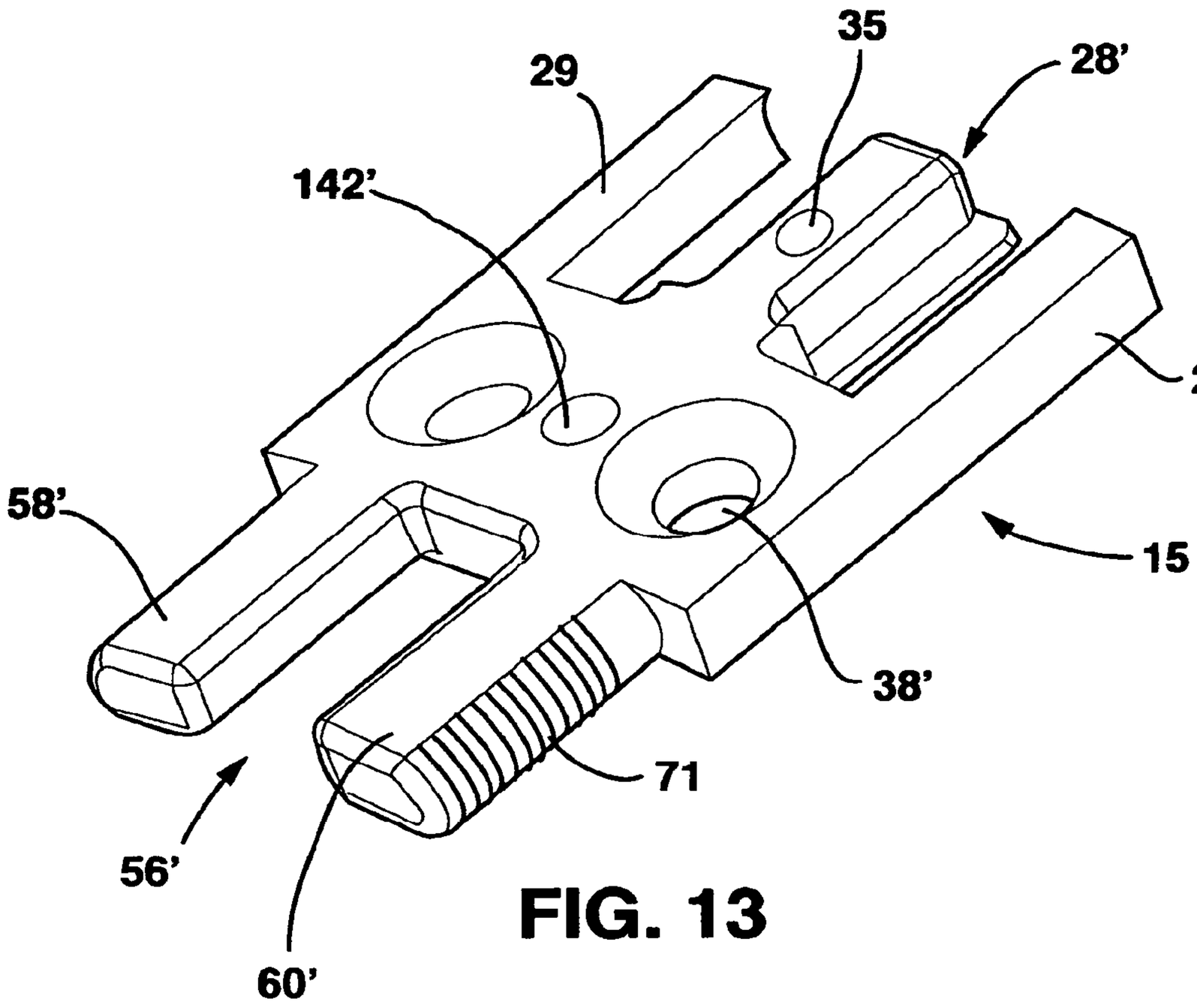

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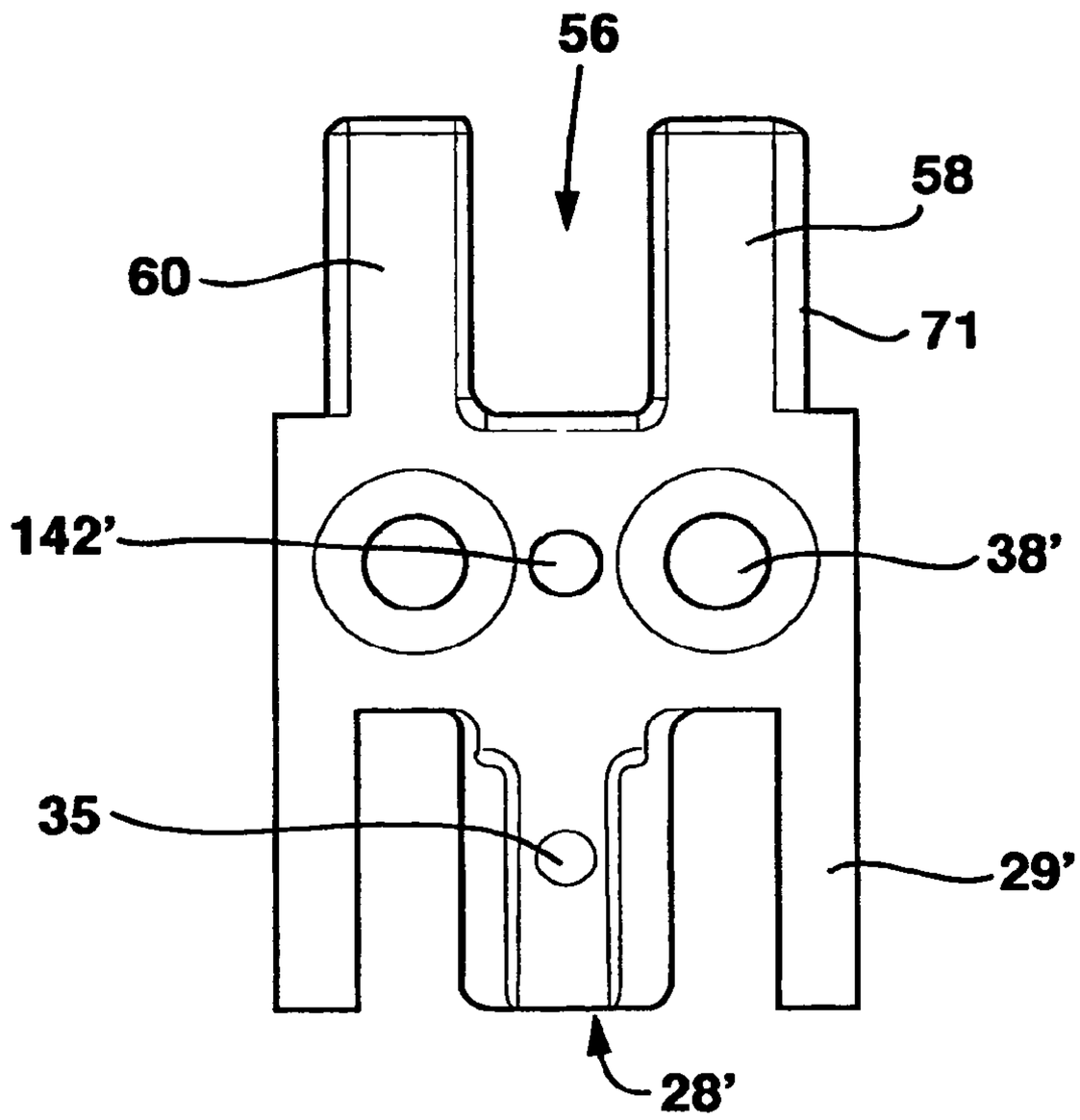

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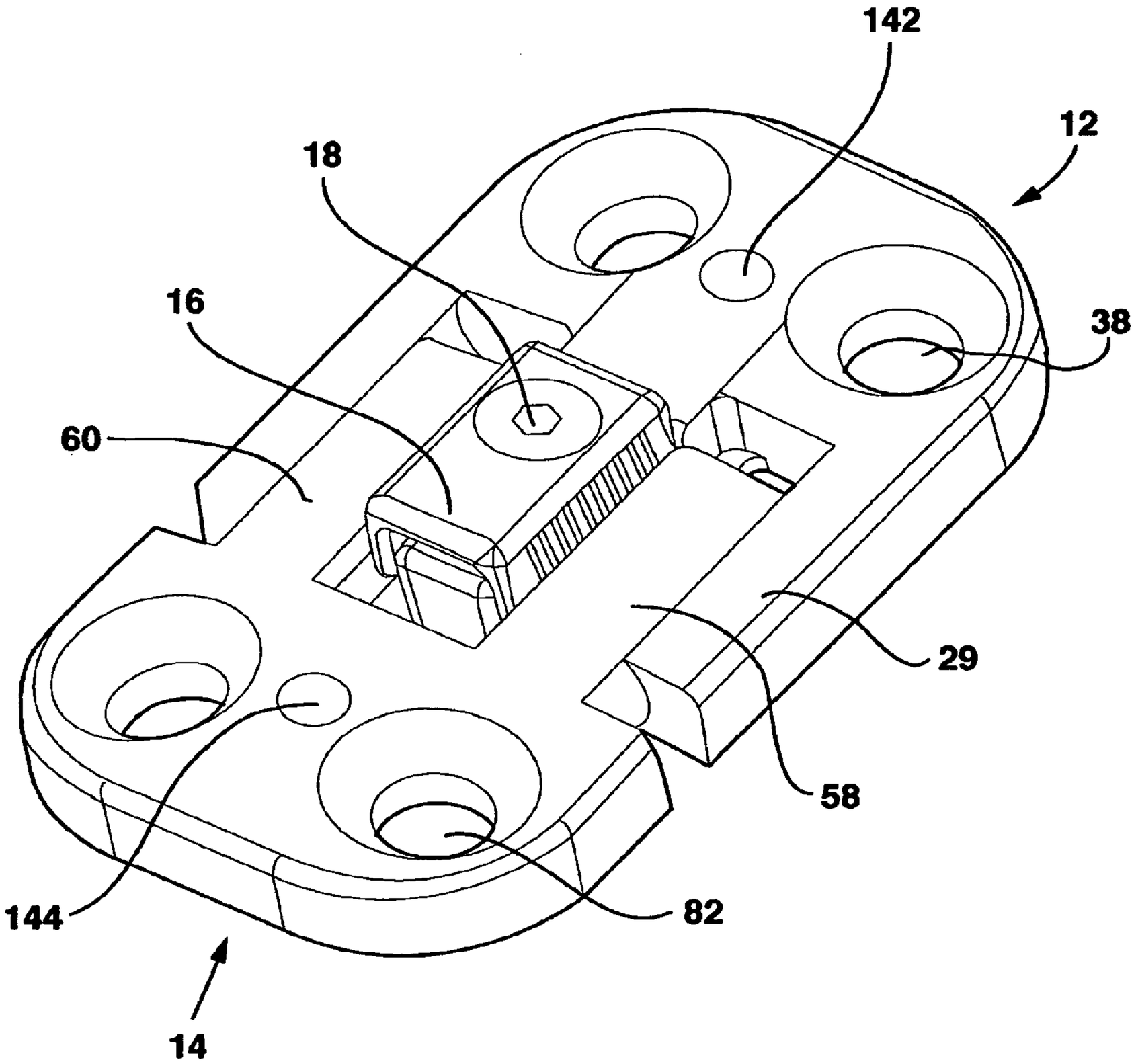

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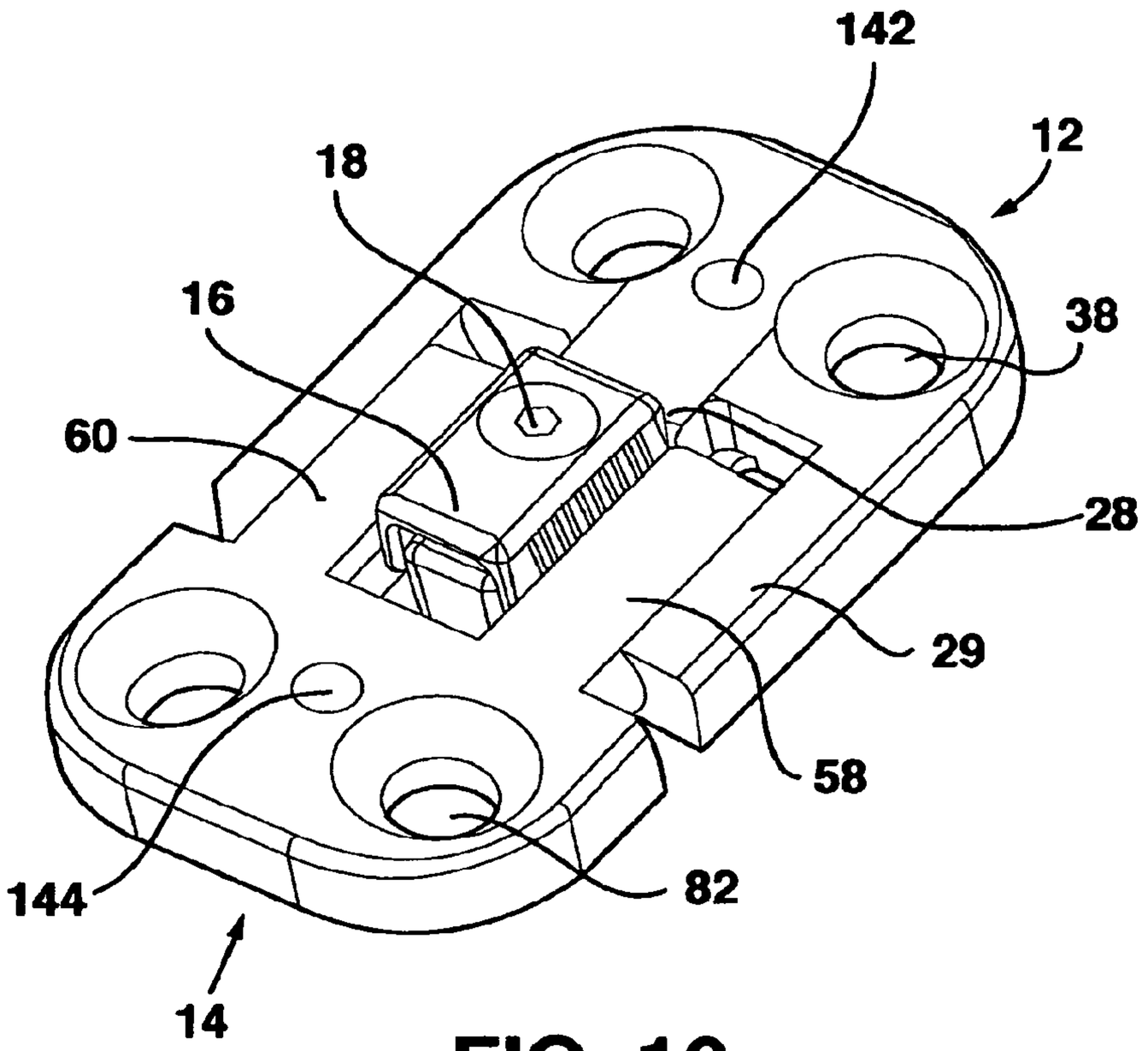

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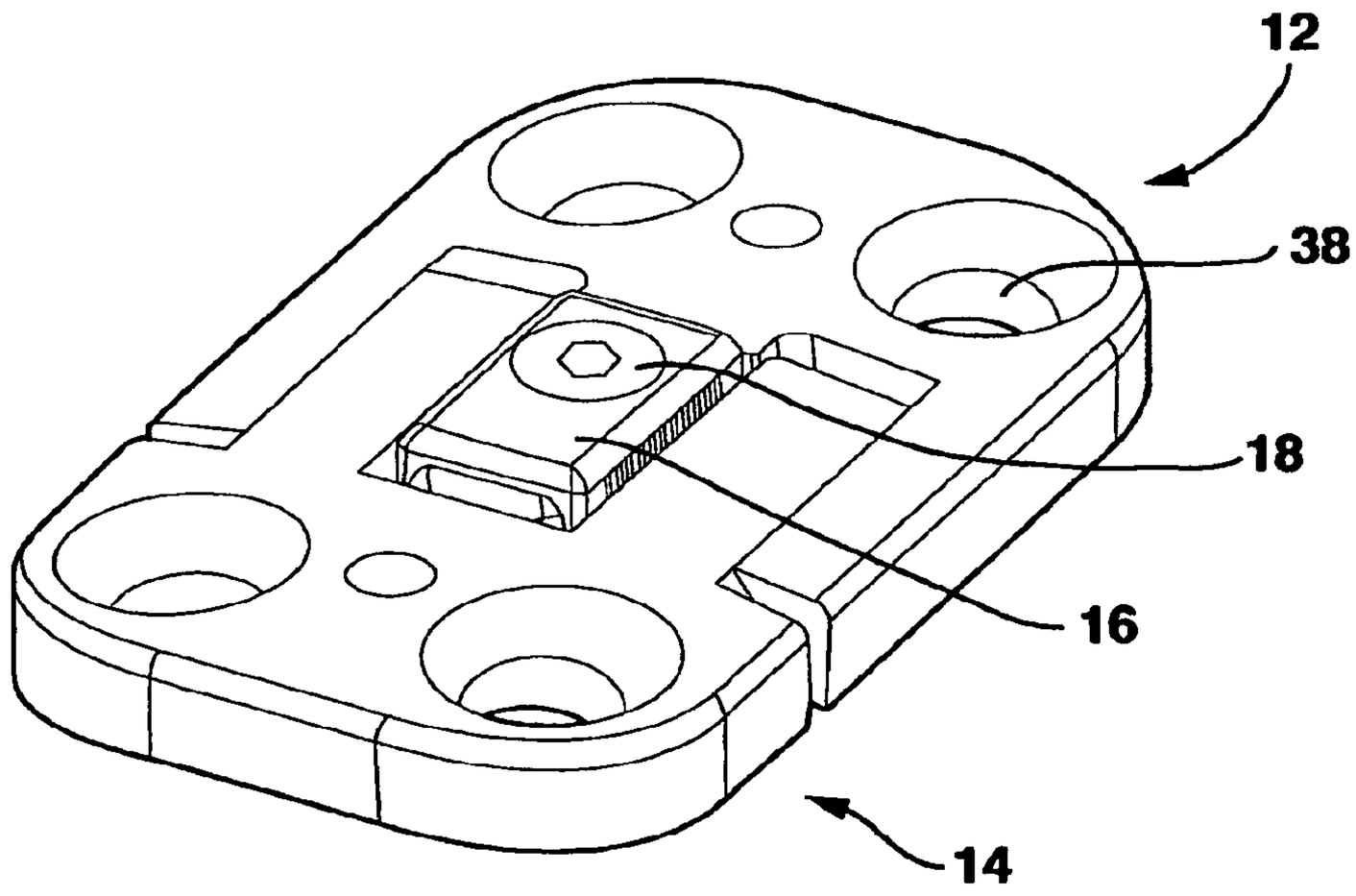

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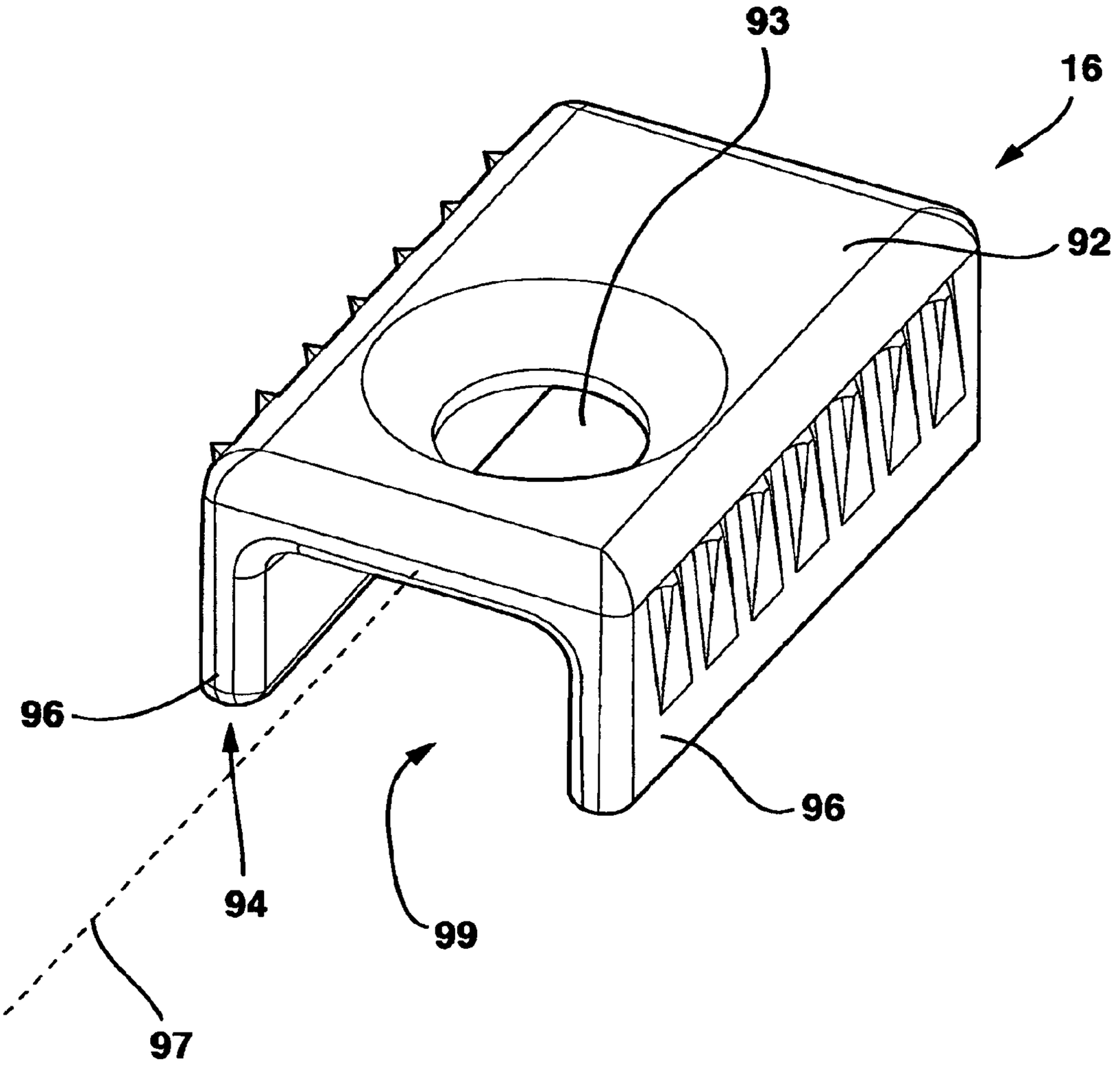

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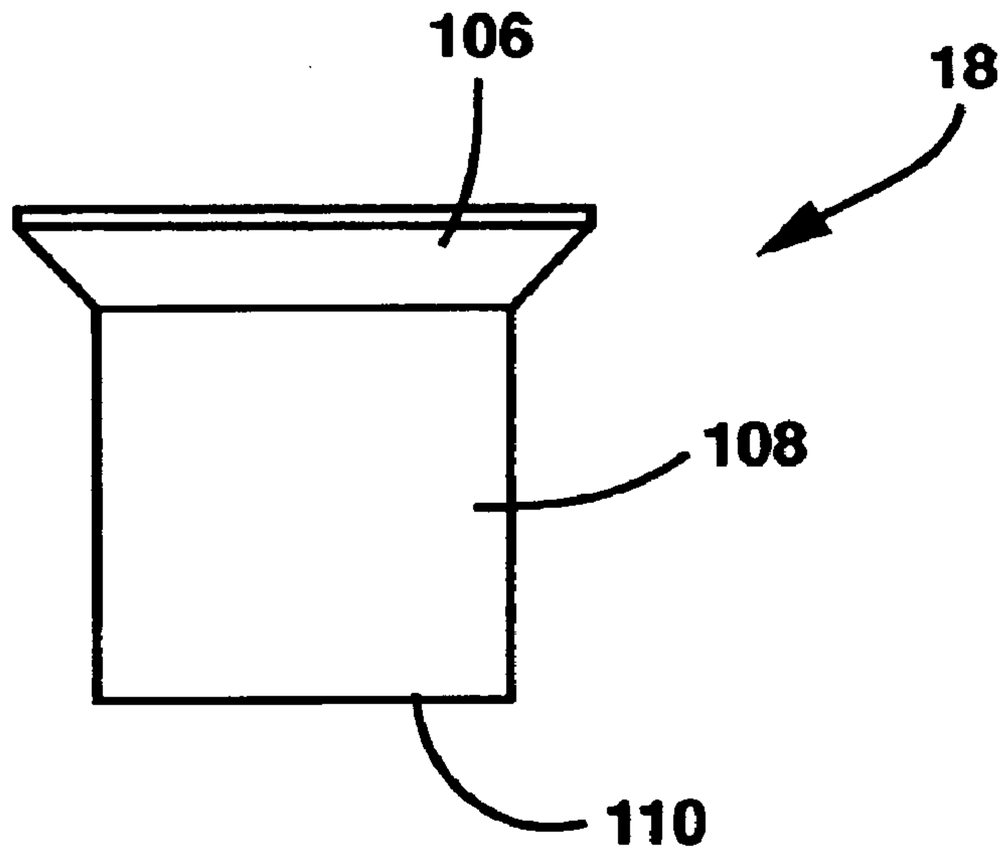

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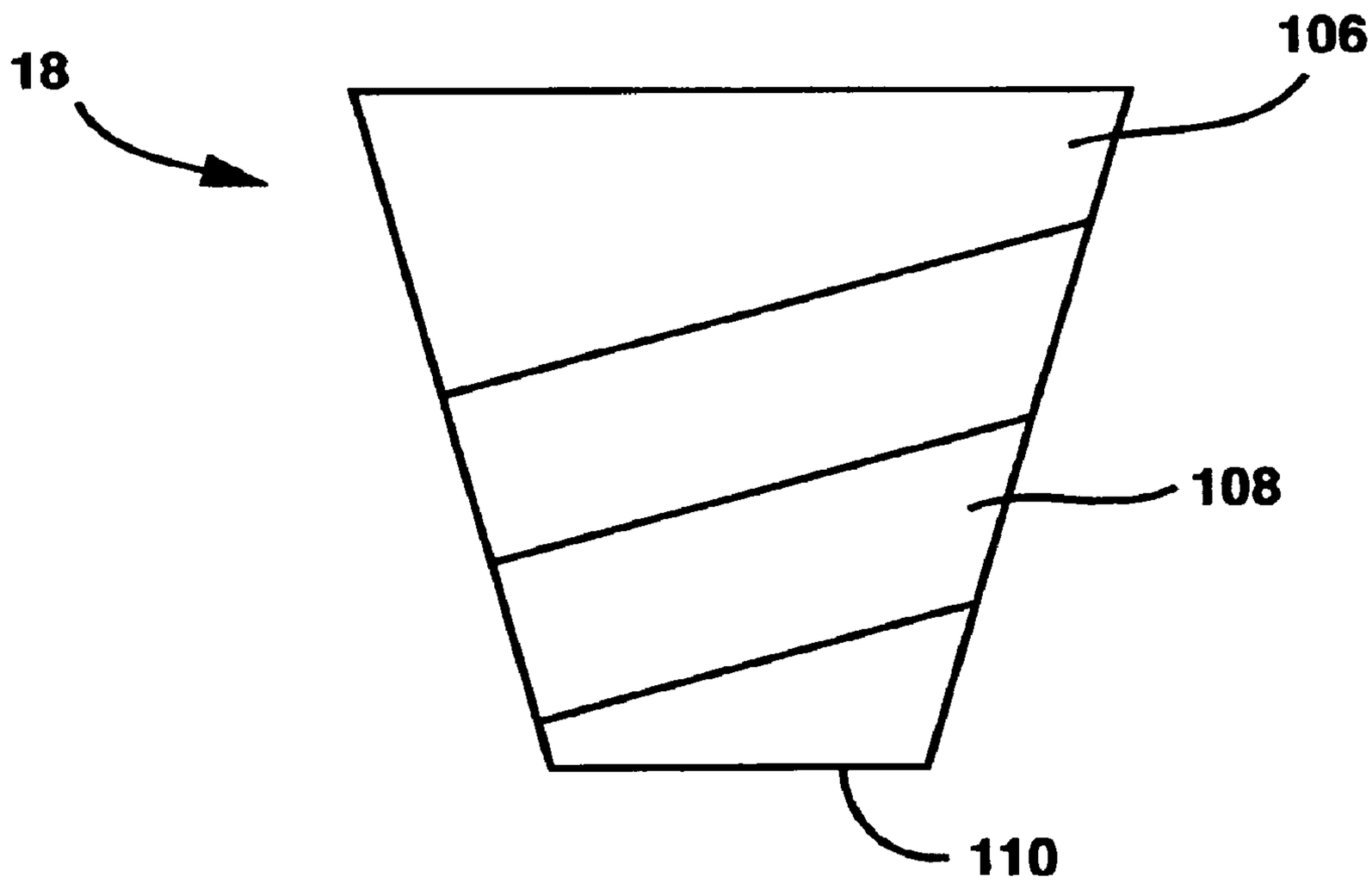

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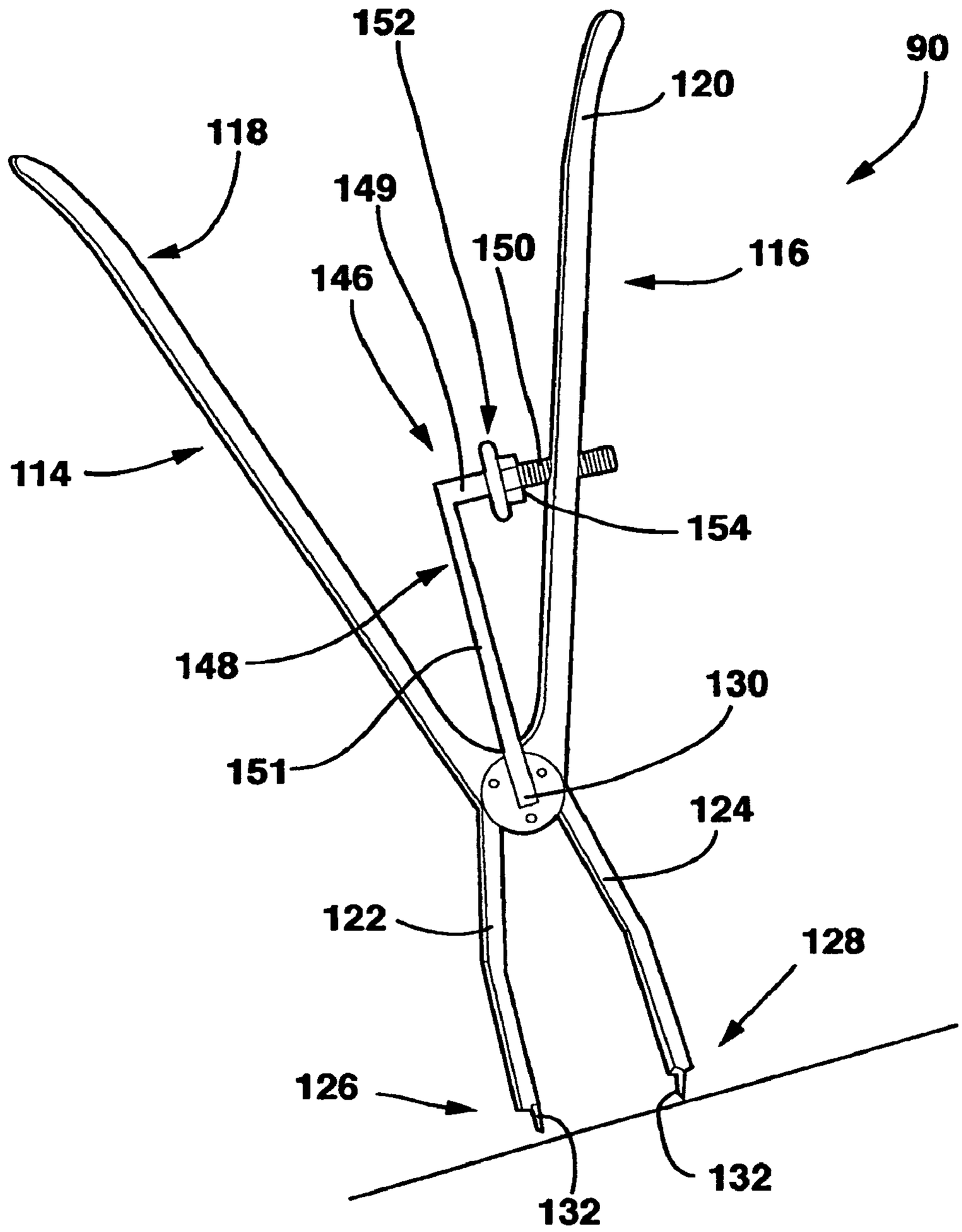
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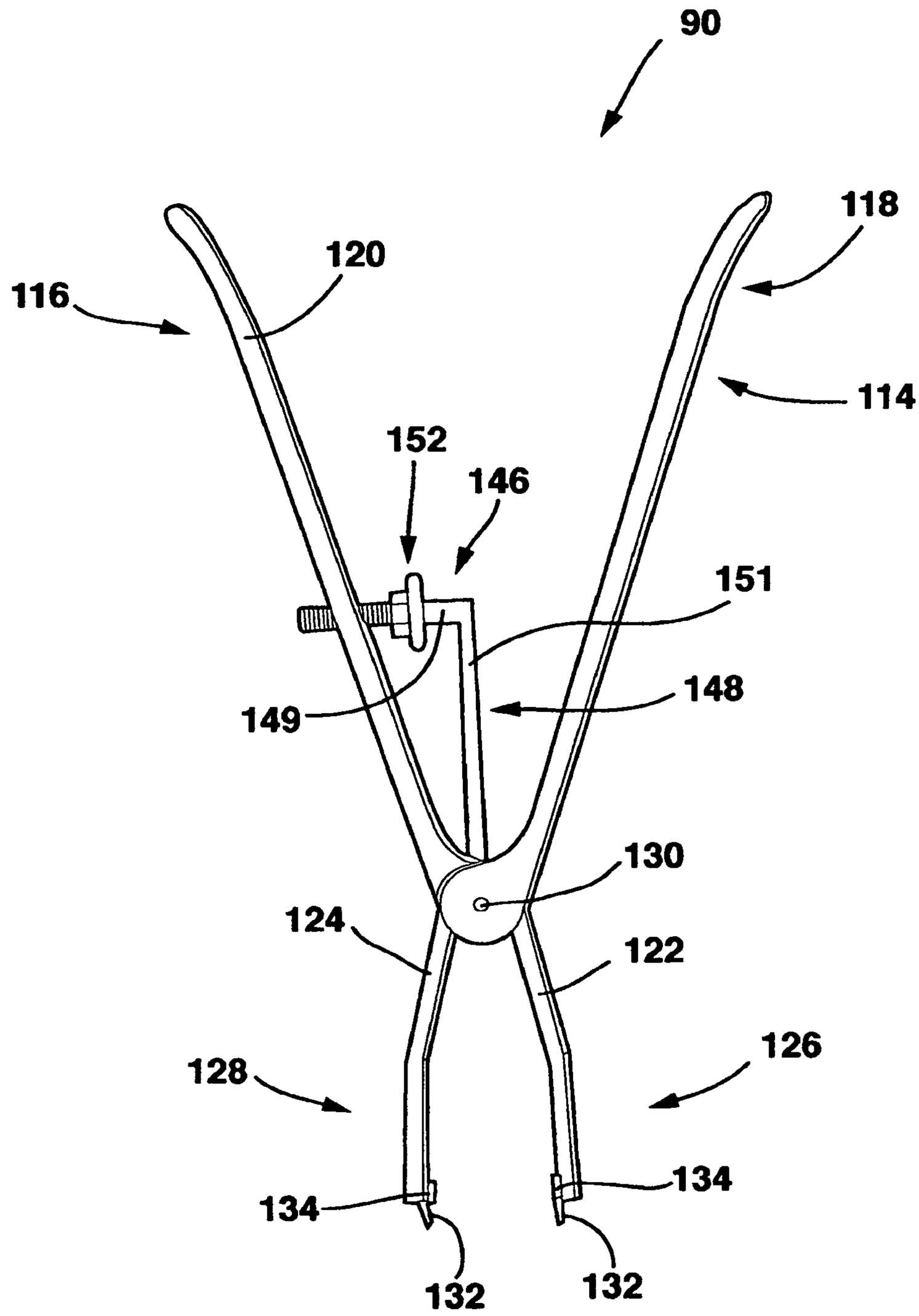
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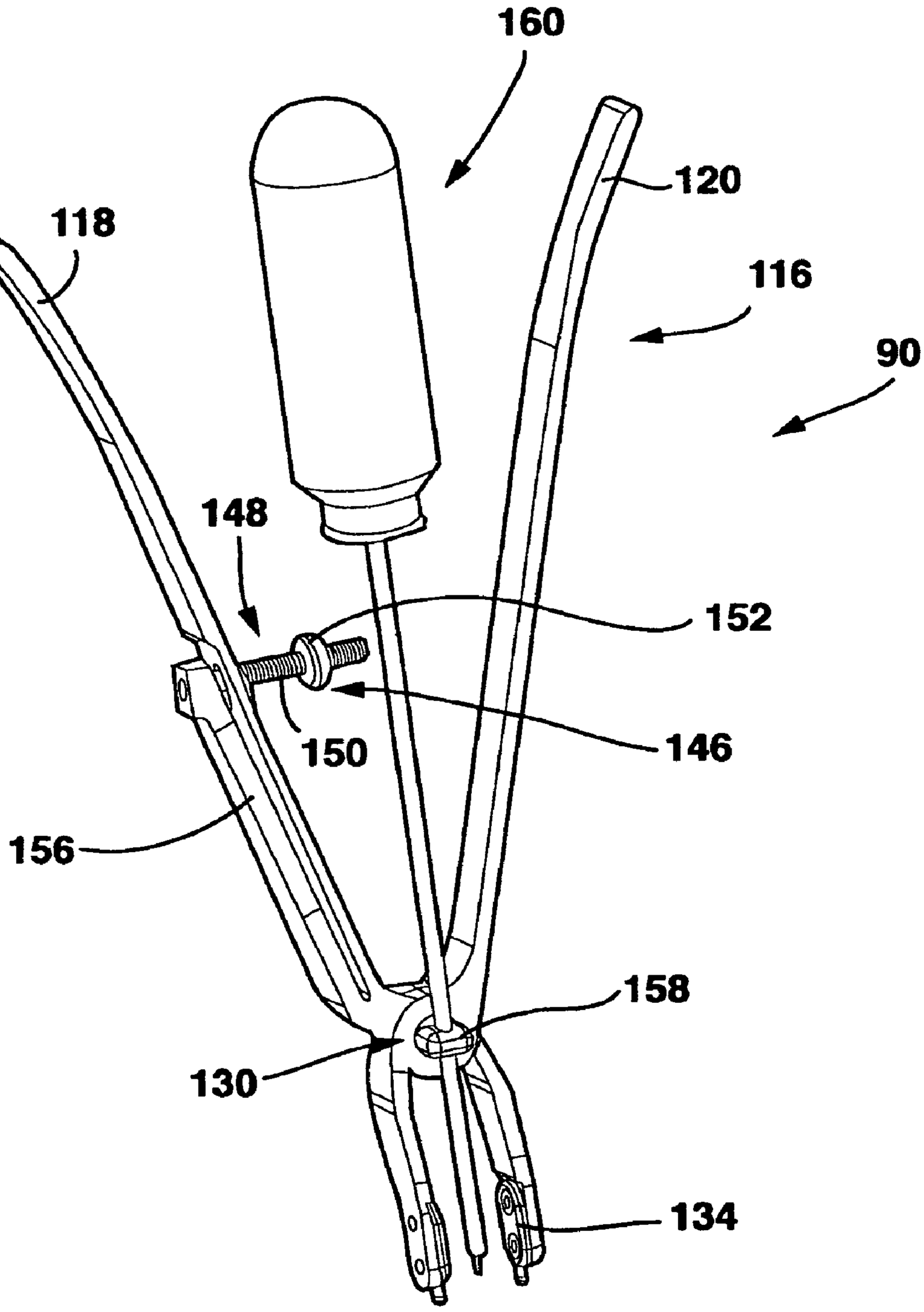

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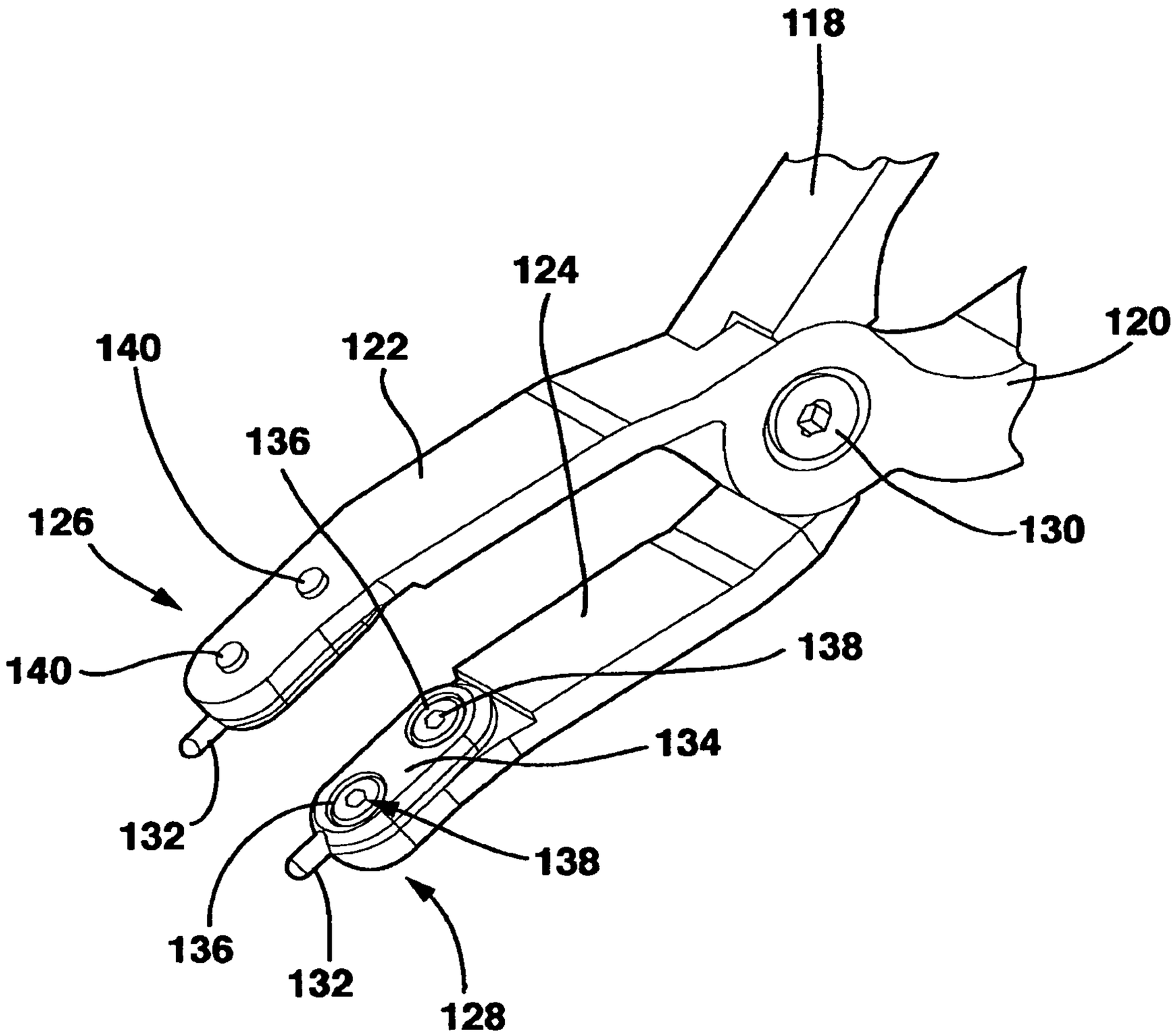

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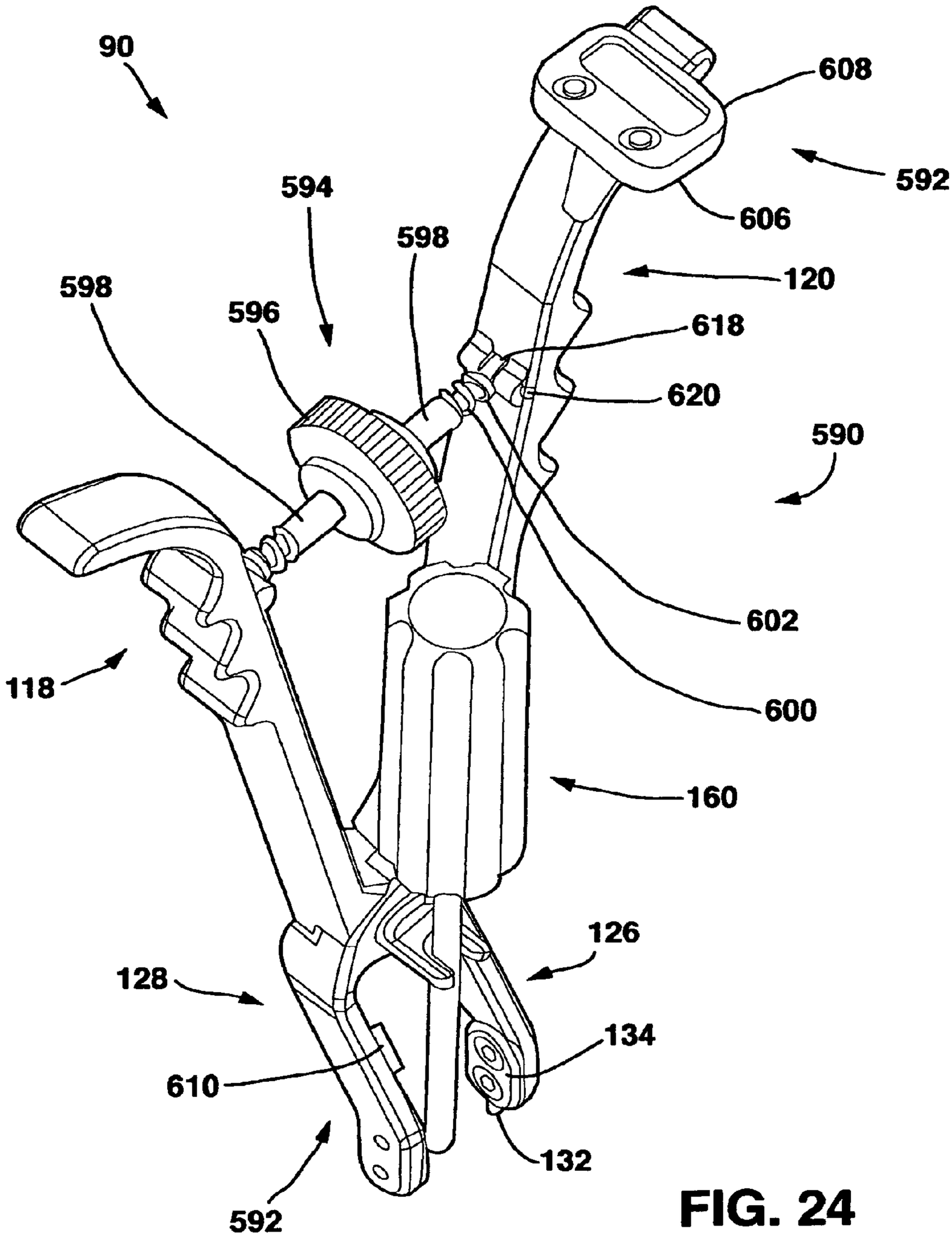
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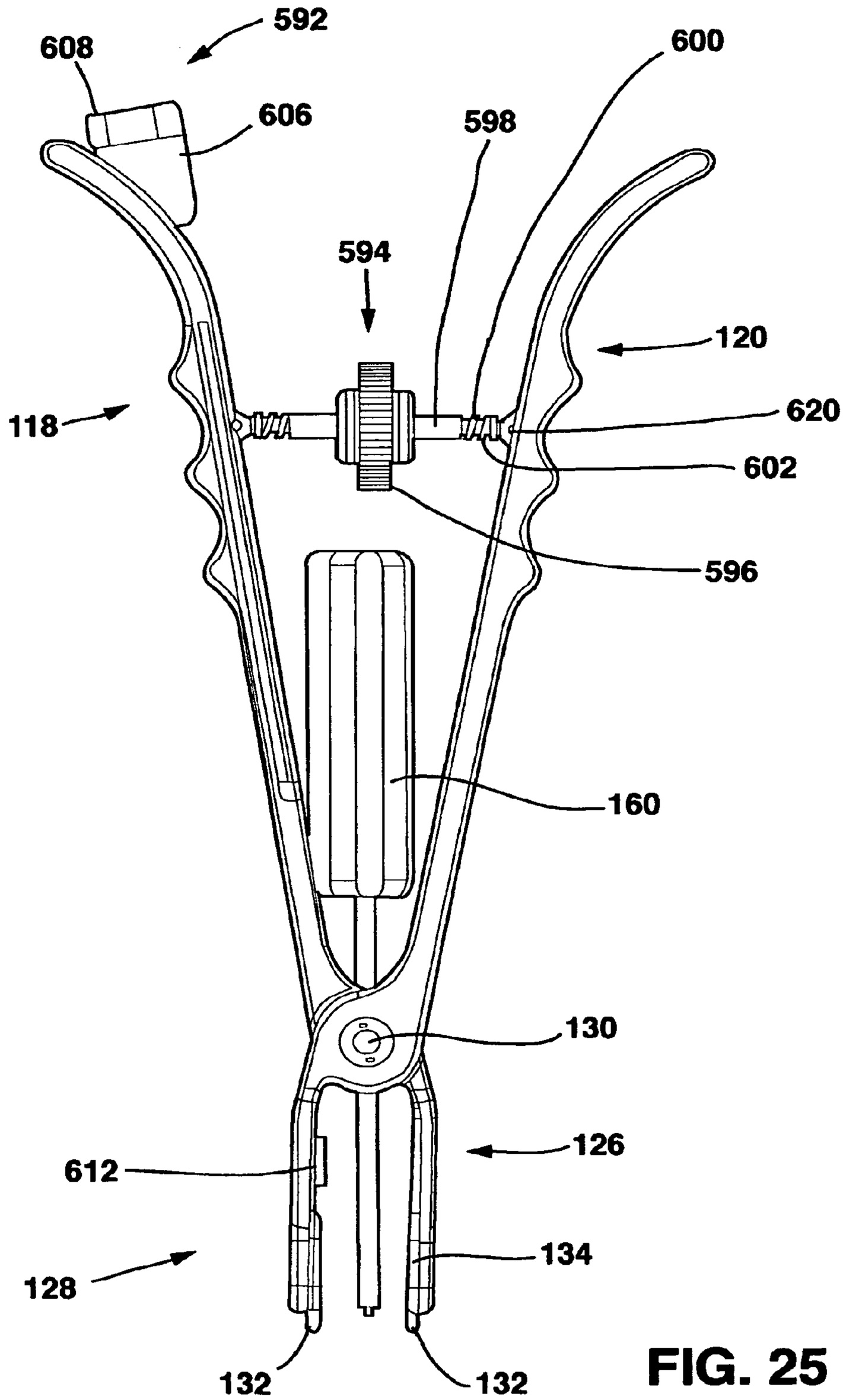
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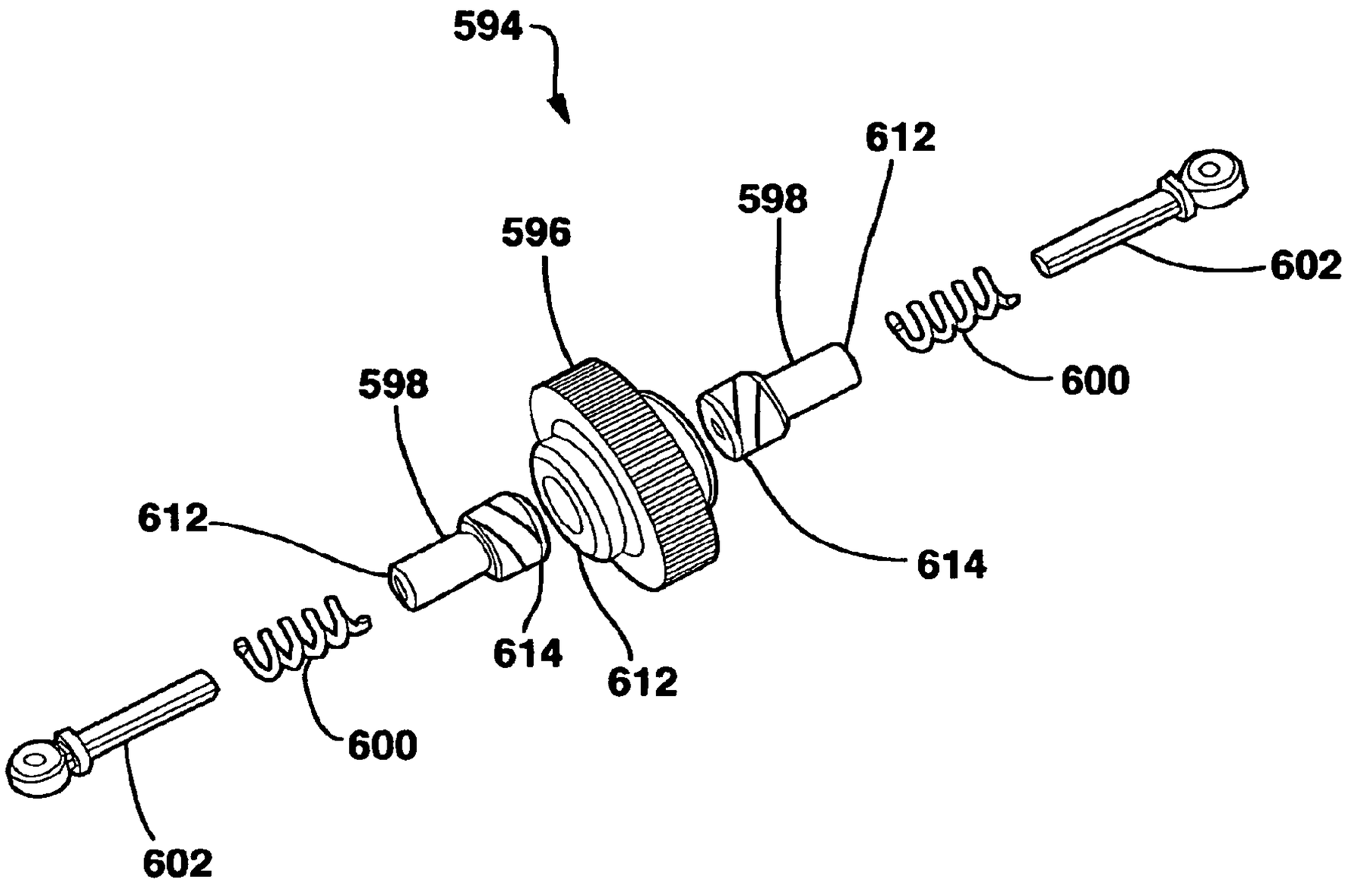

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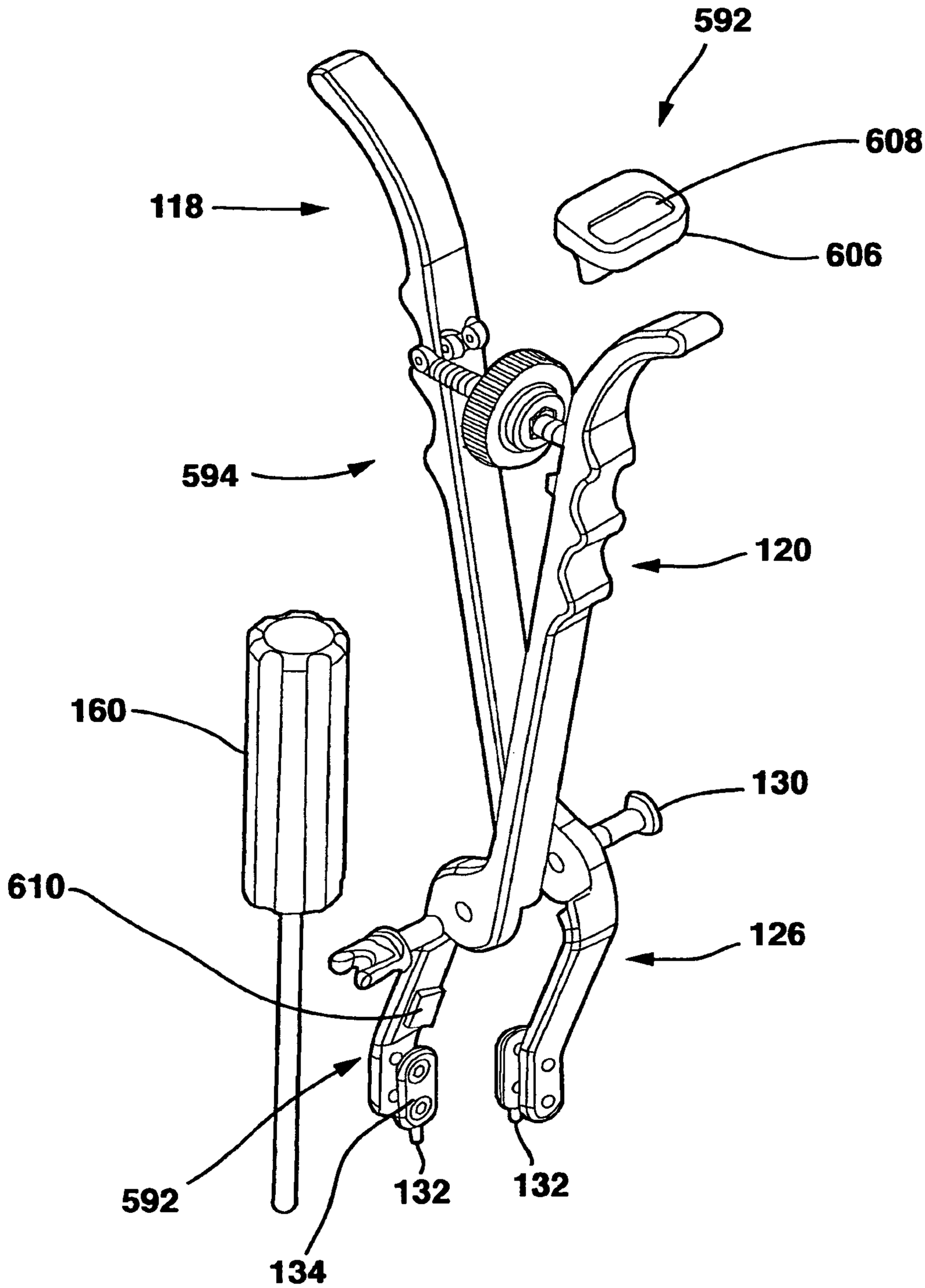

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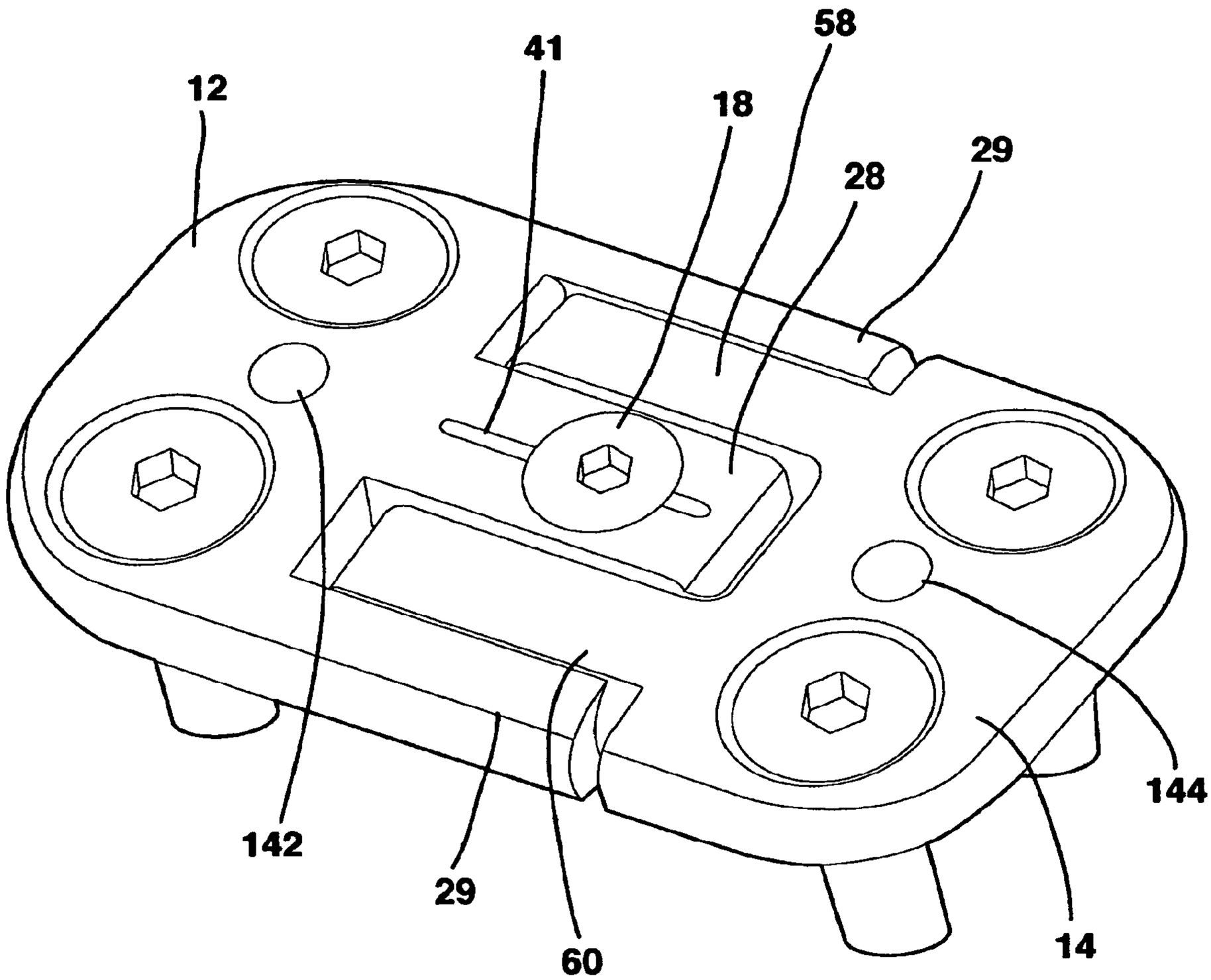

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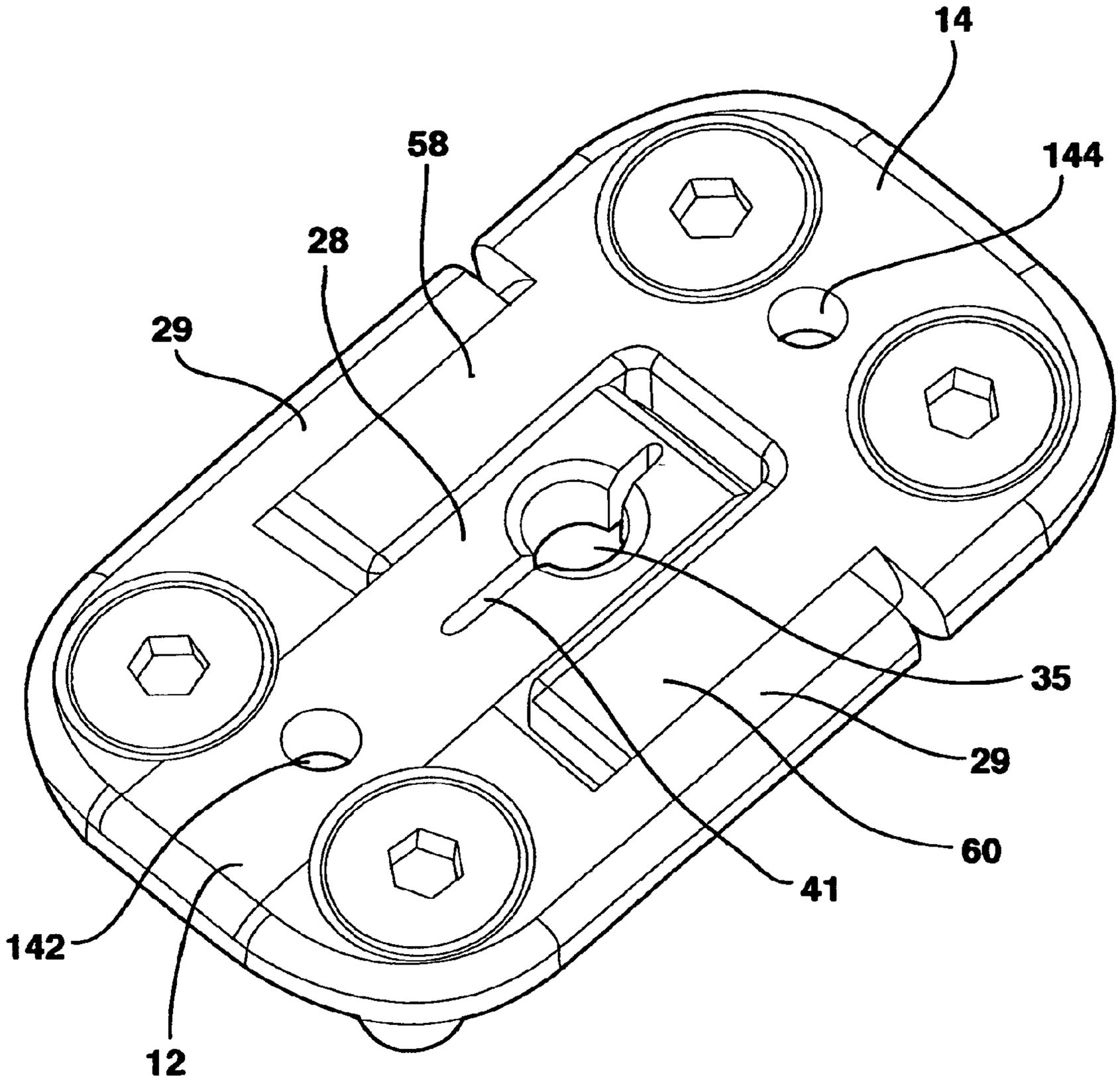

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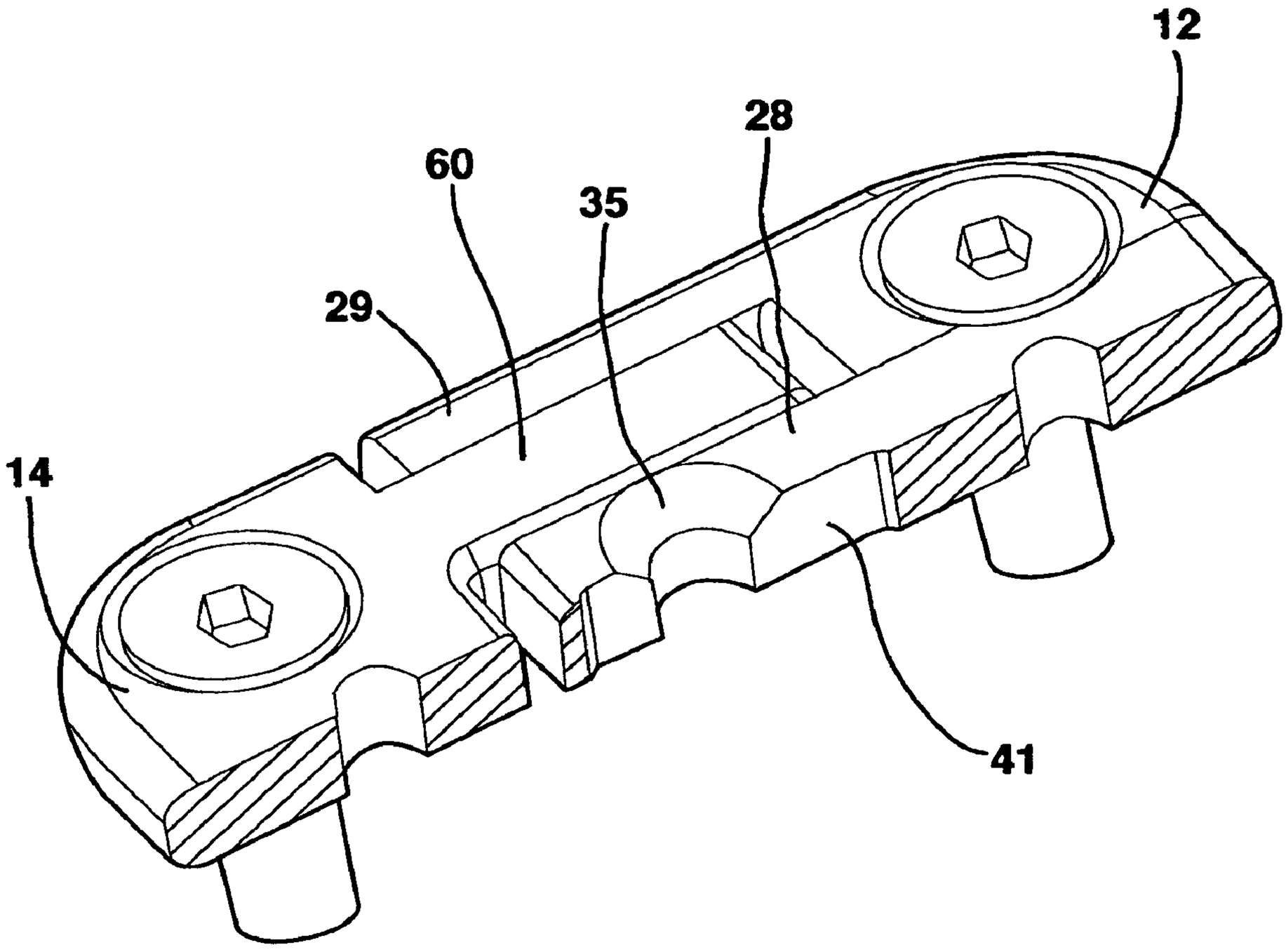

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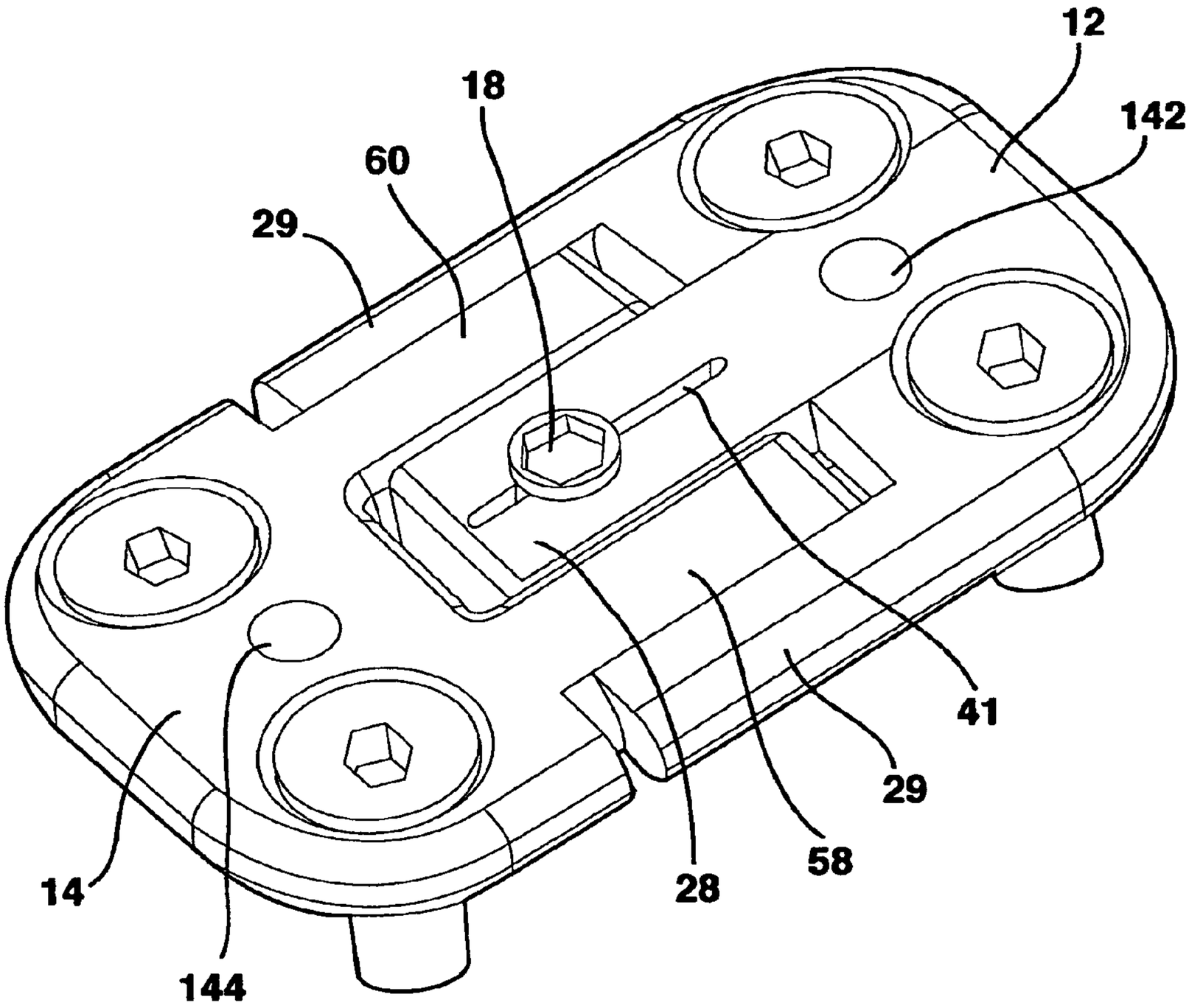

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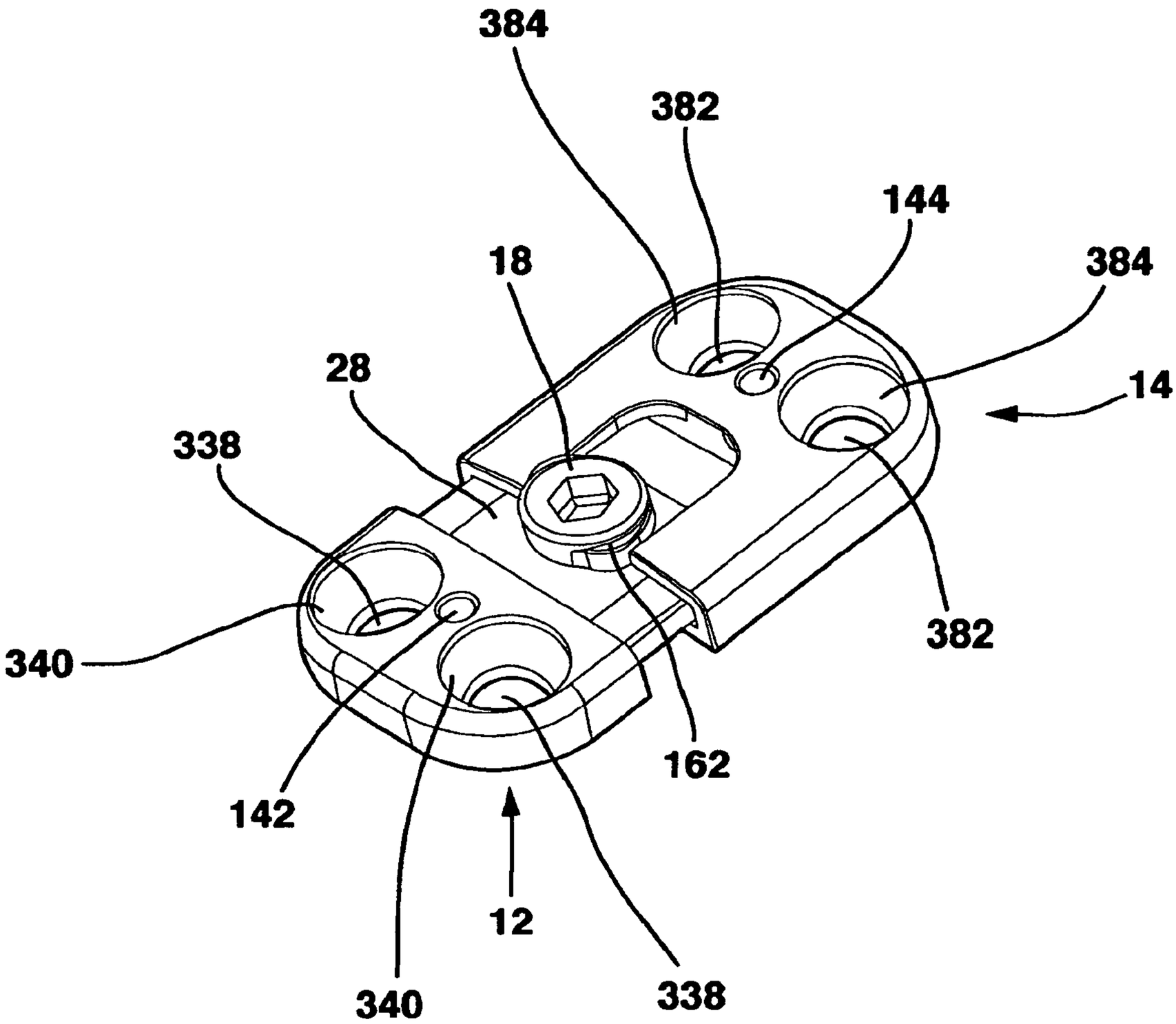

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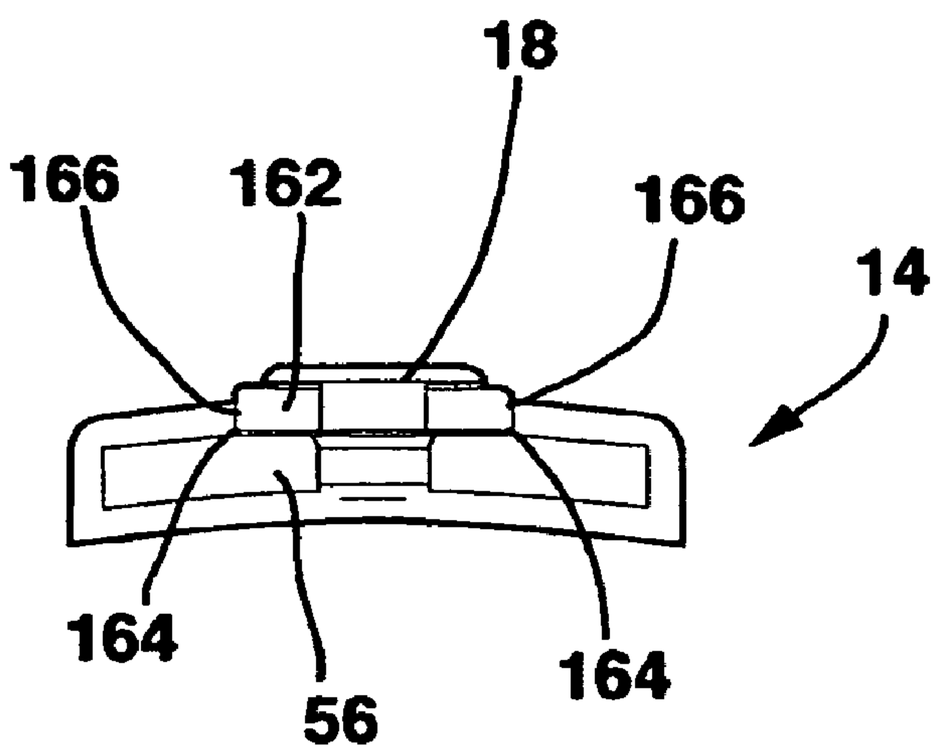

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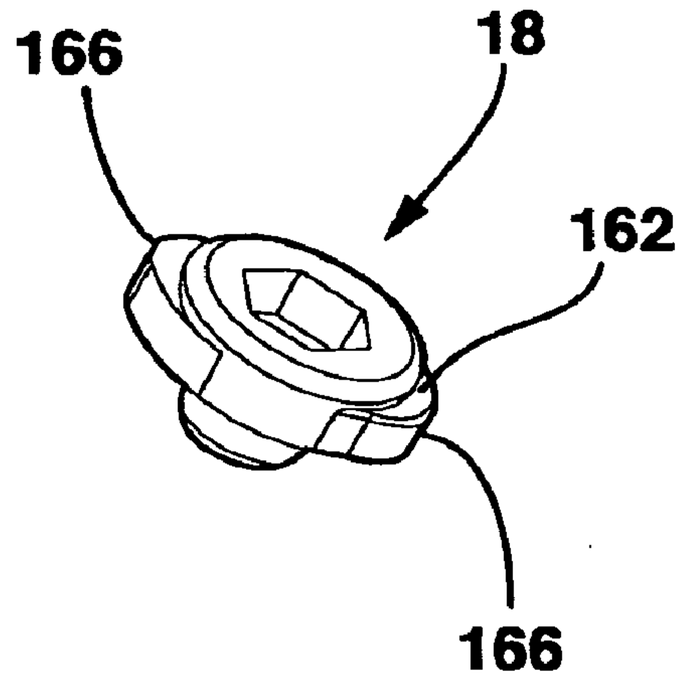

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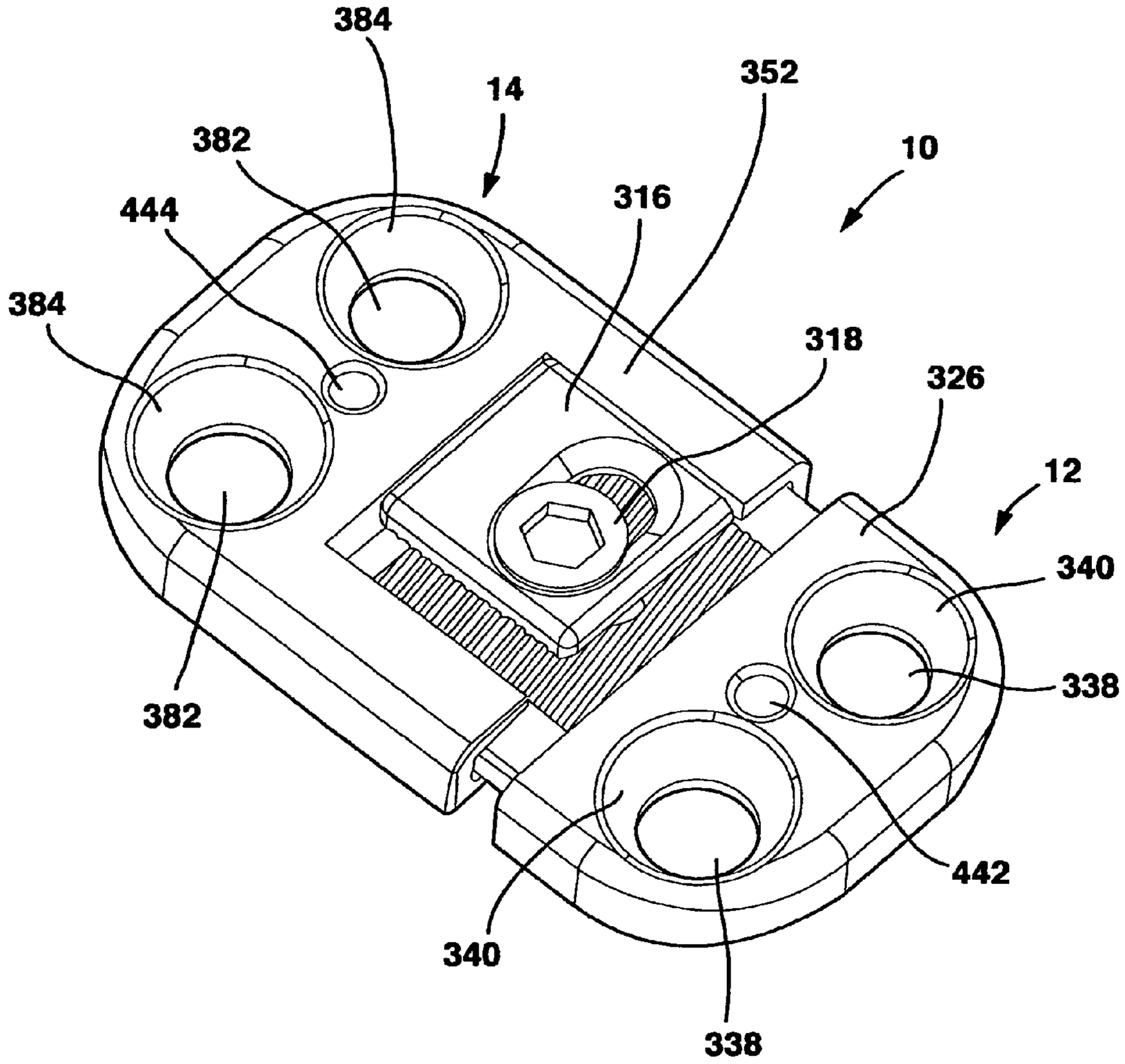

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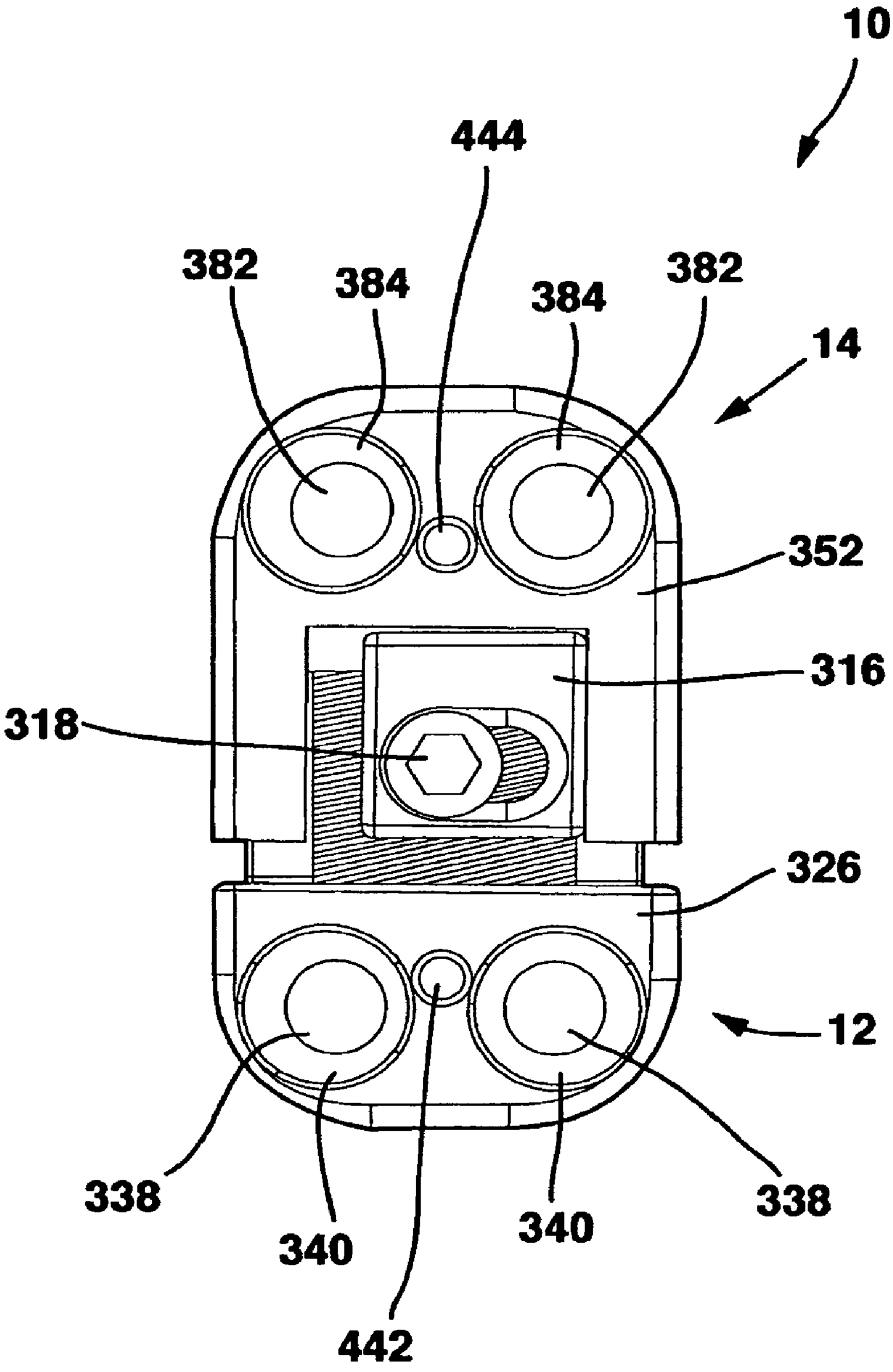

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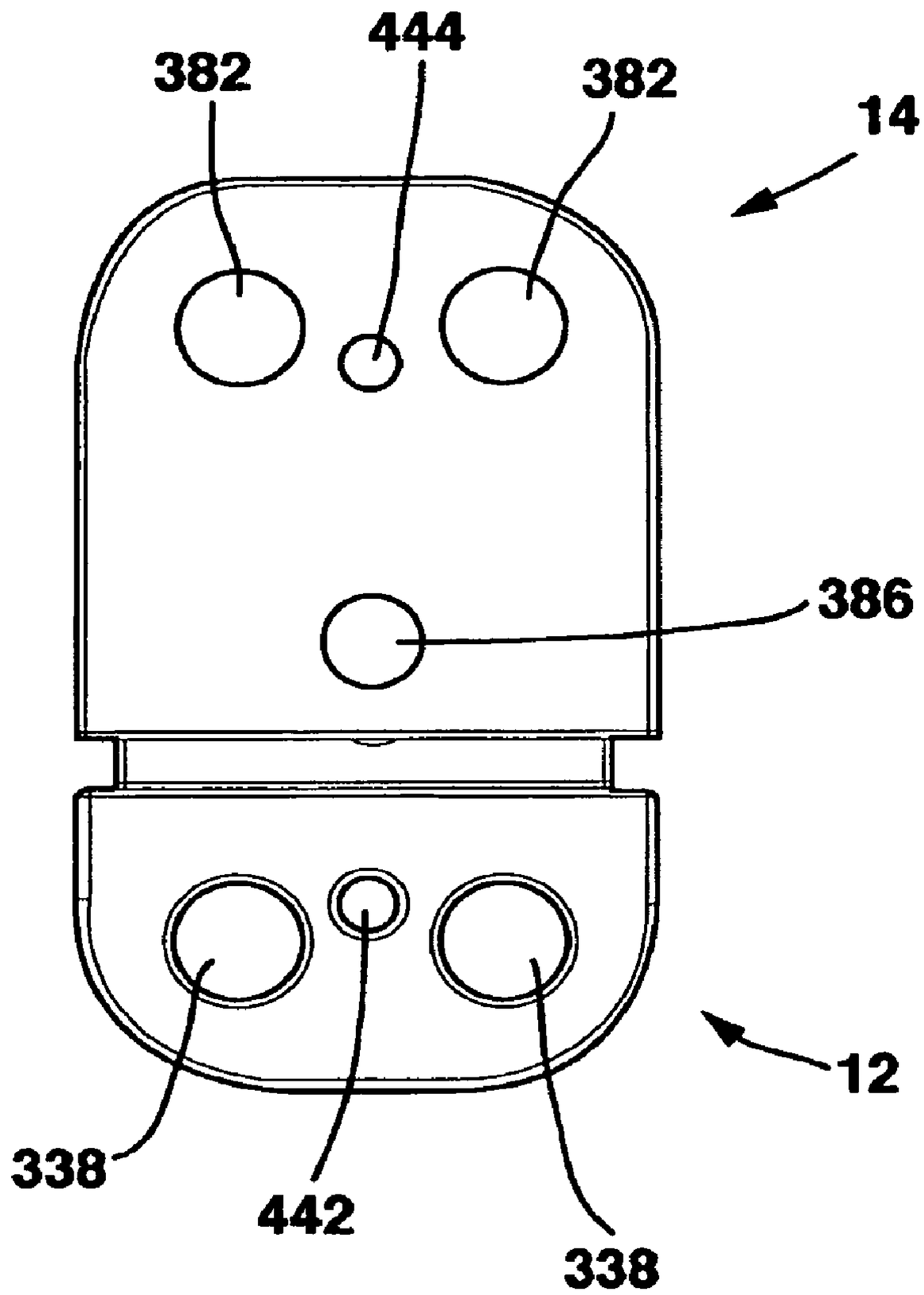

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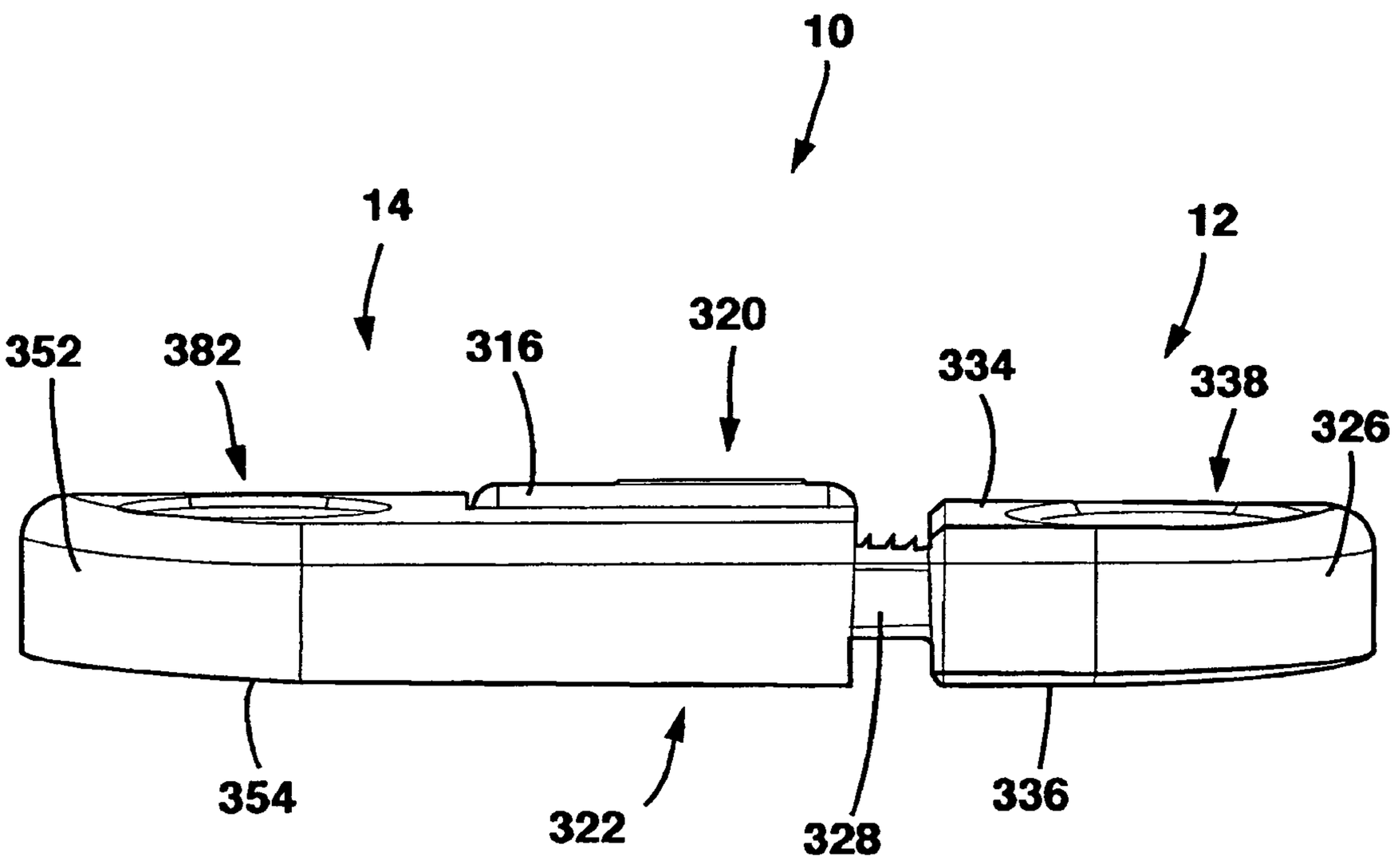

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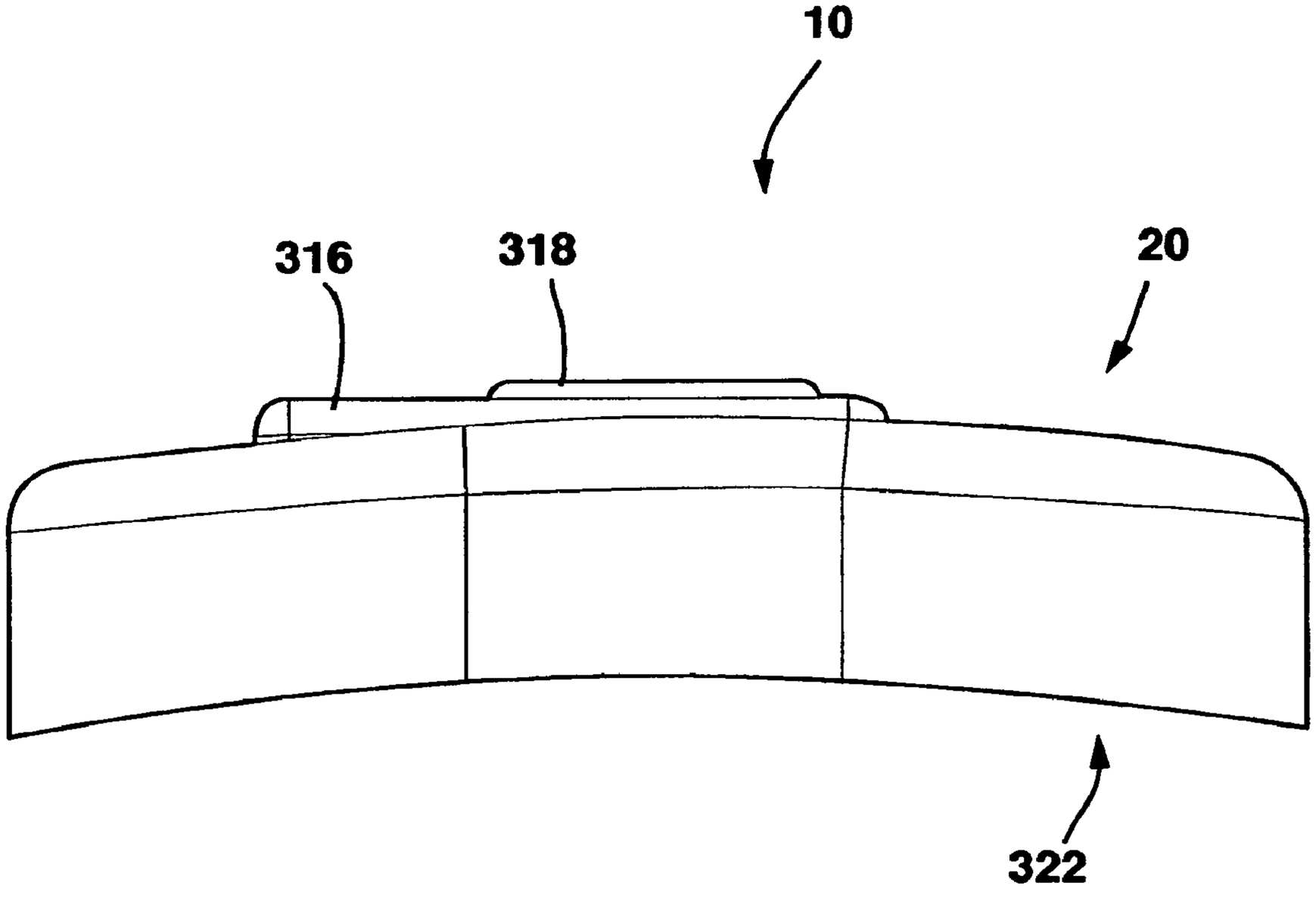

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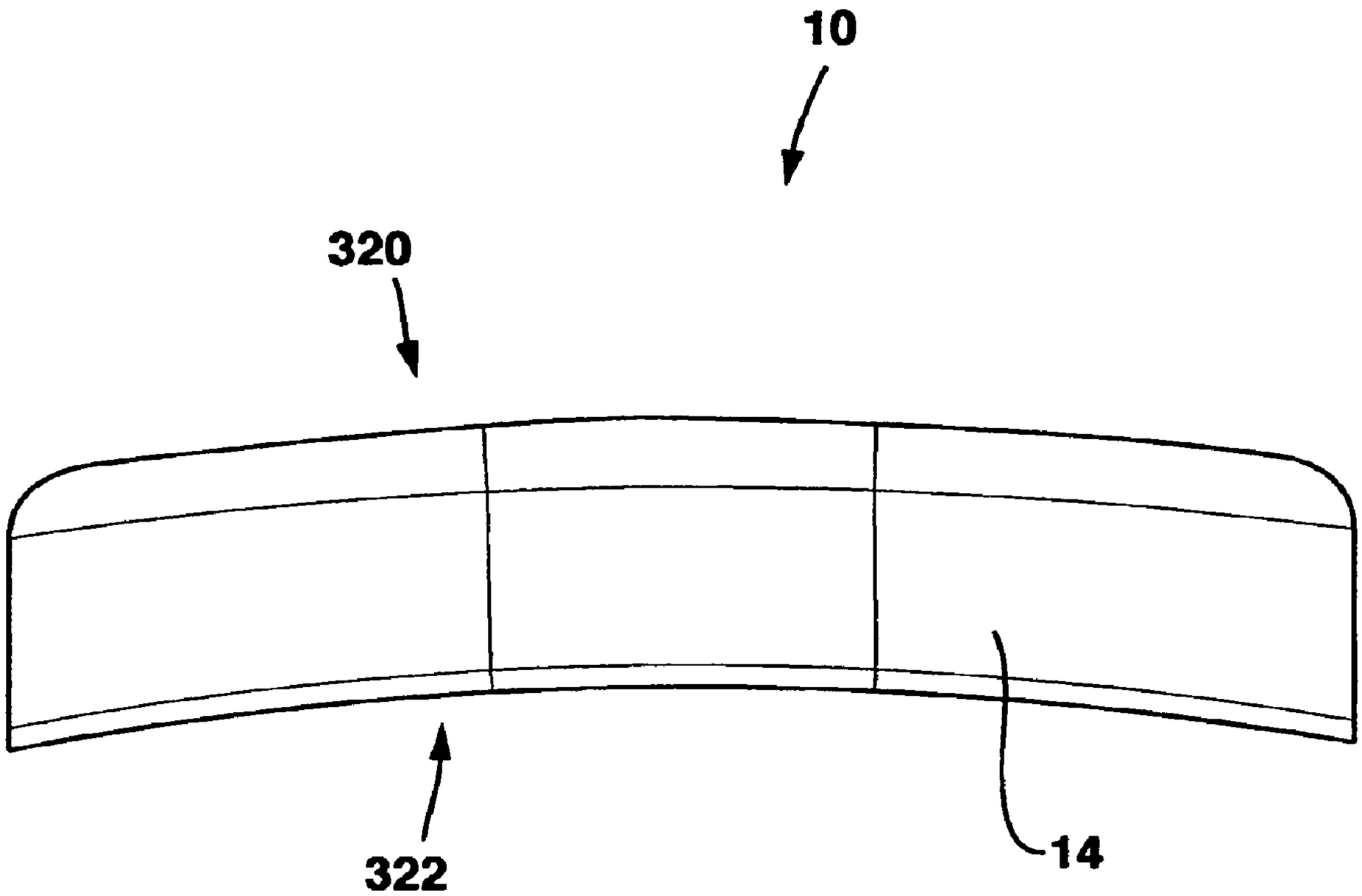

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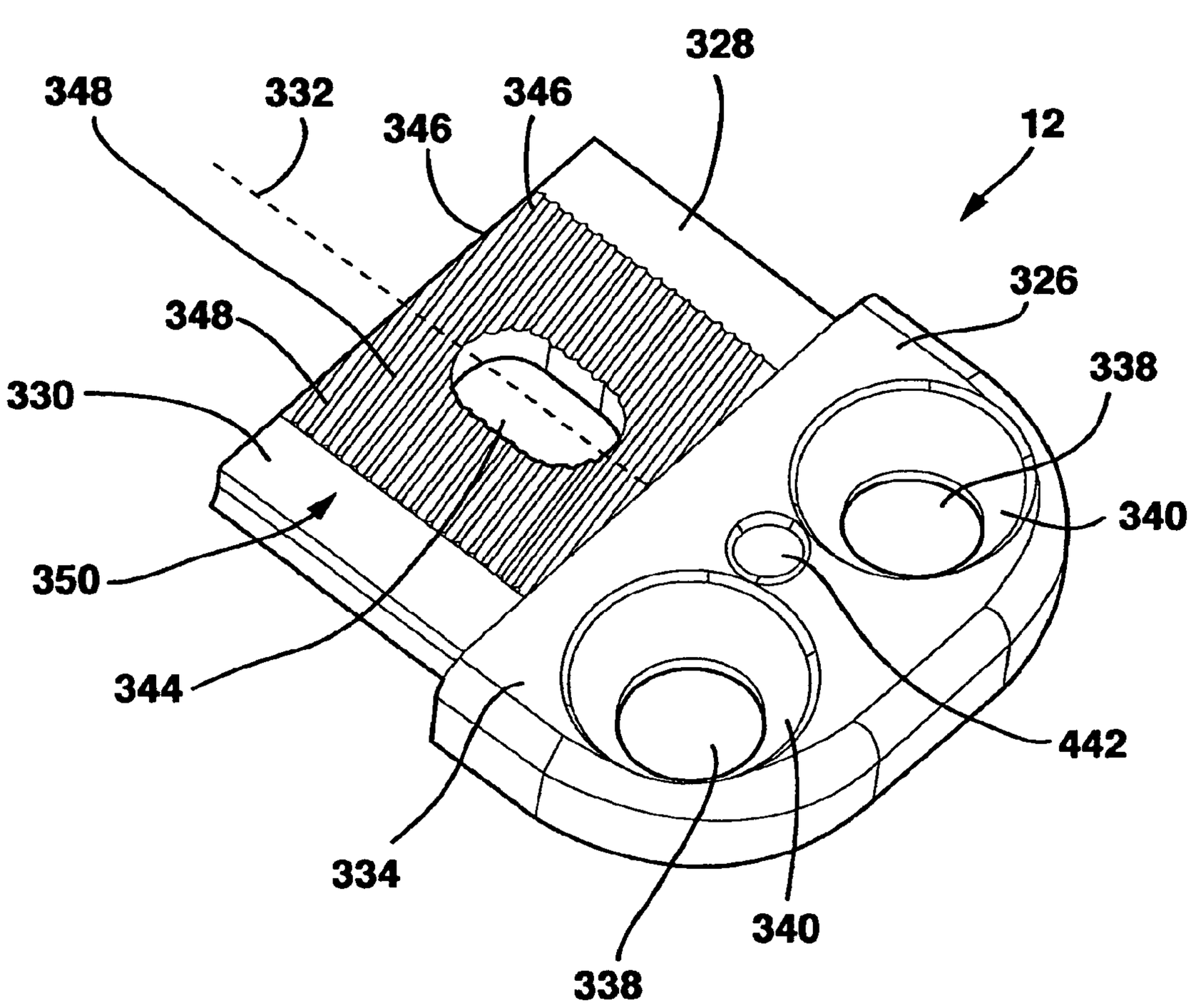
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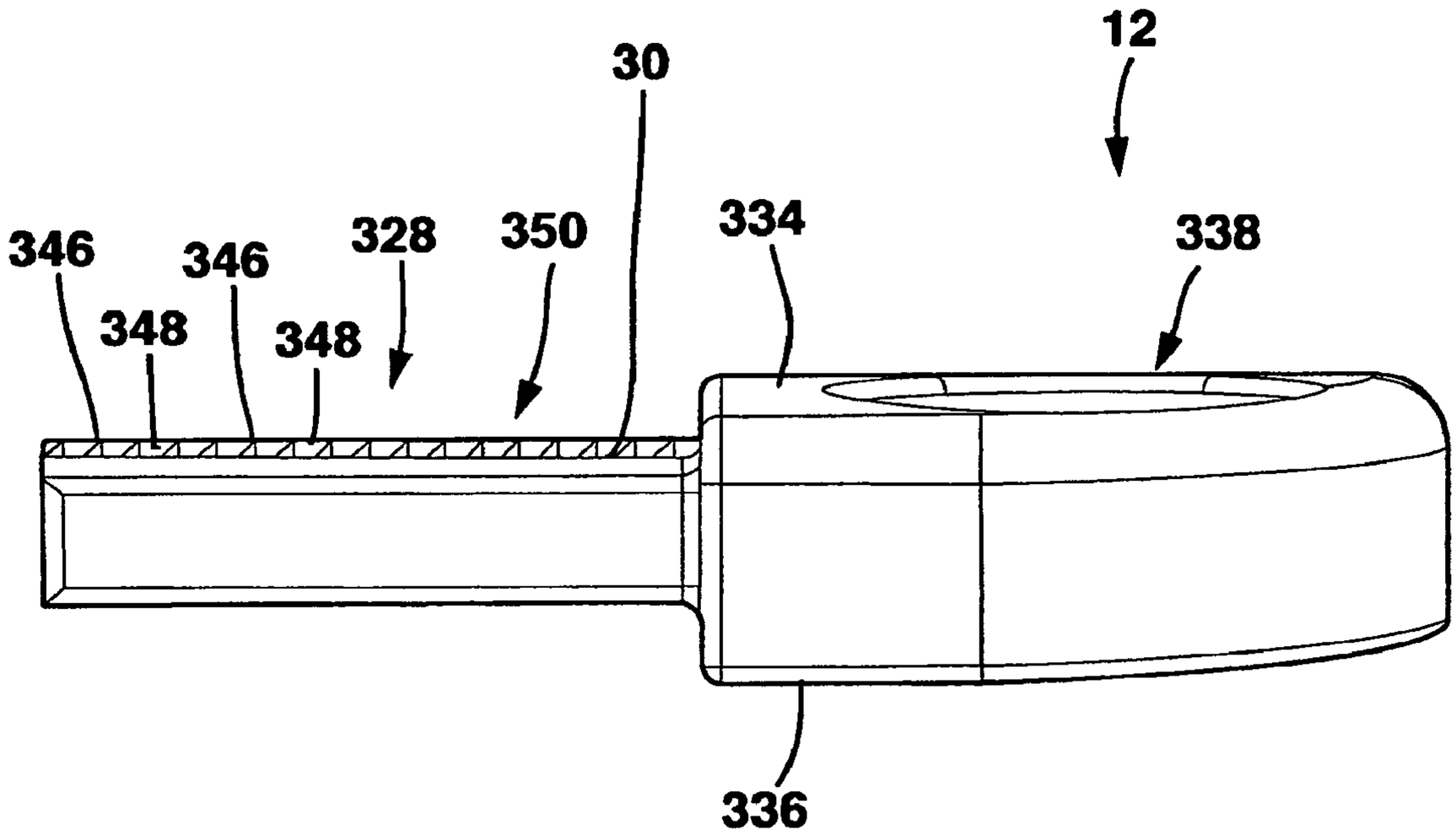
FIG. 42



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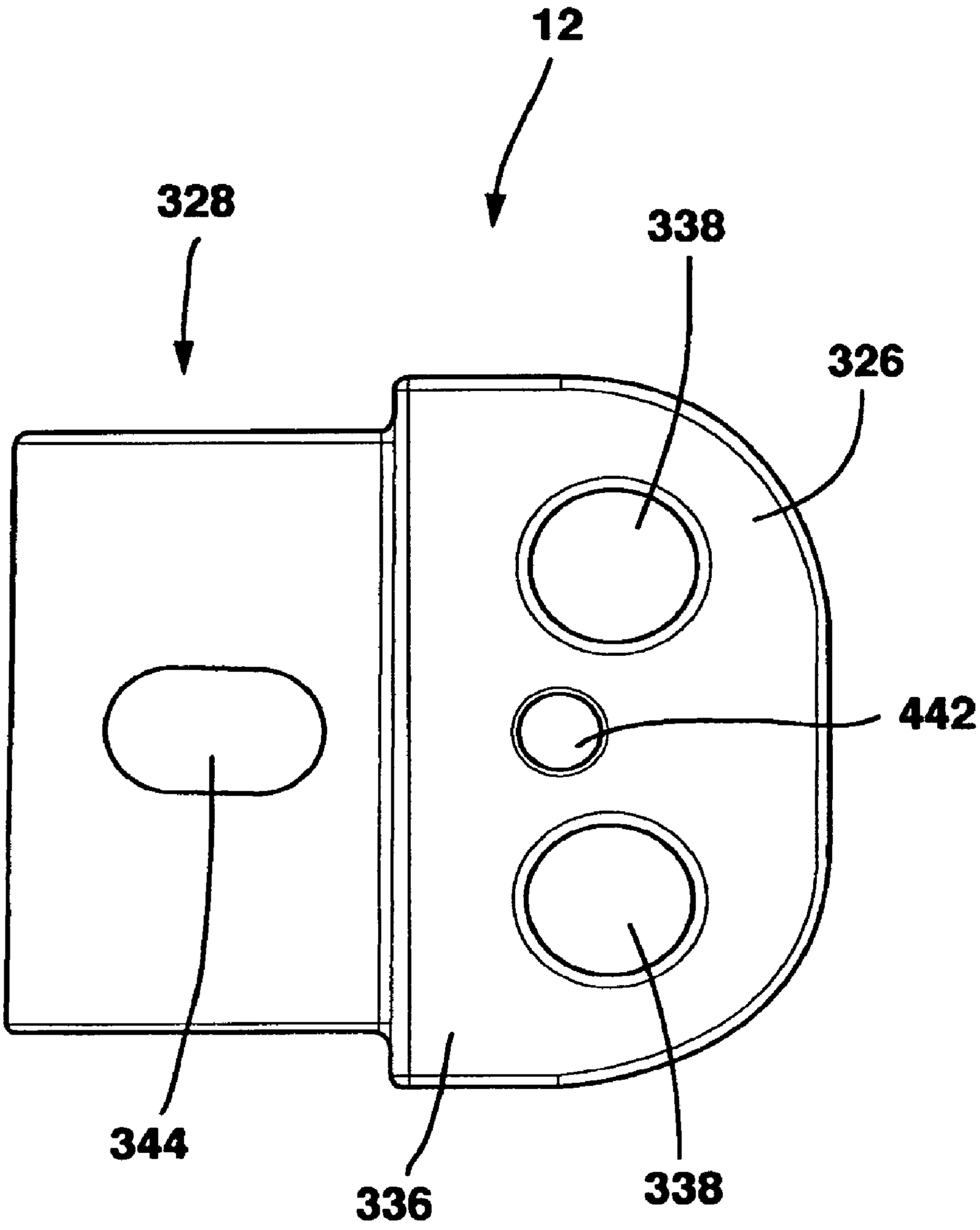

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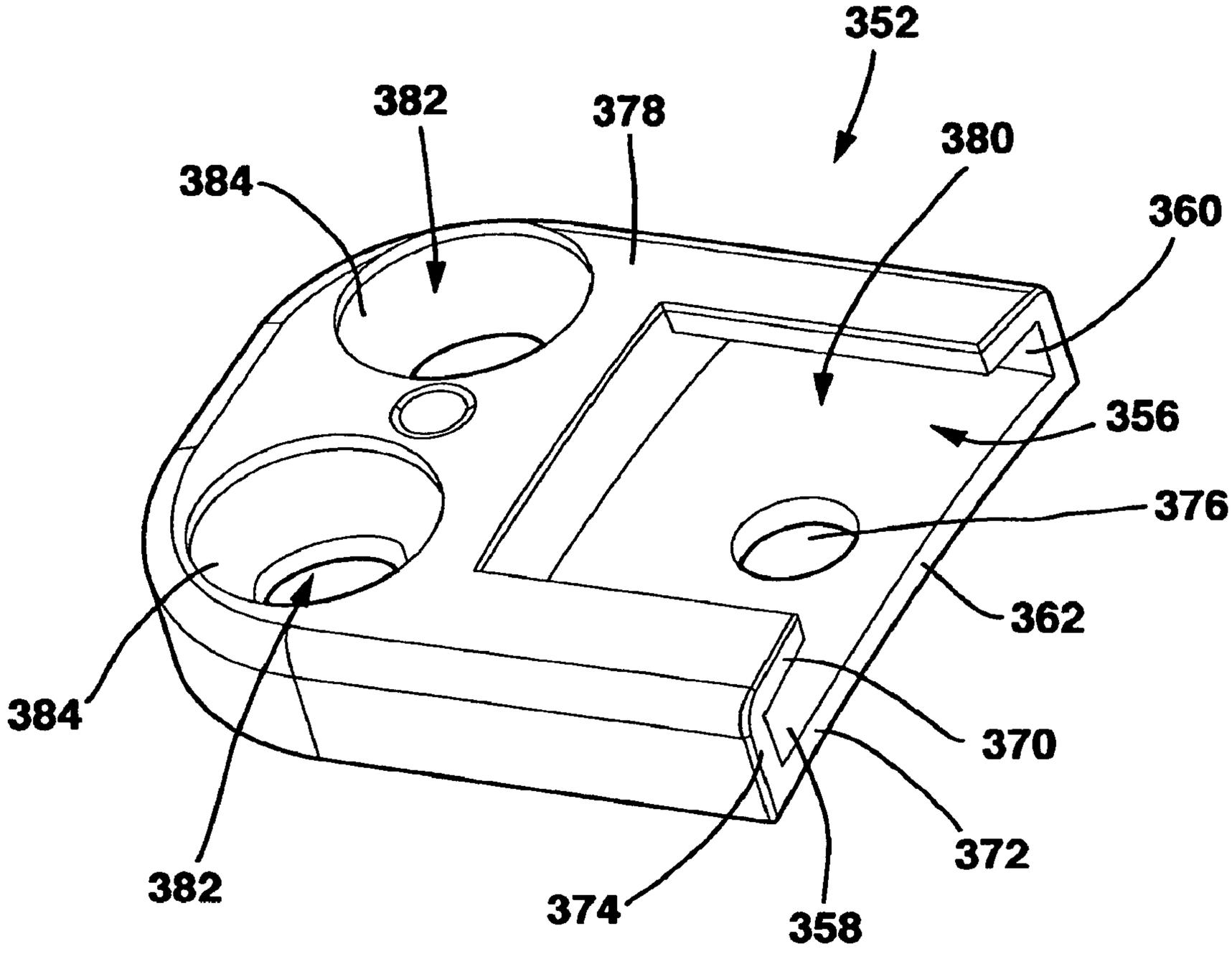


FIG. 45

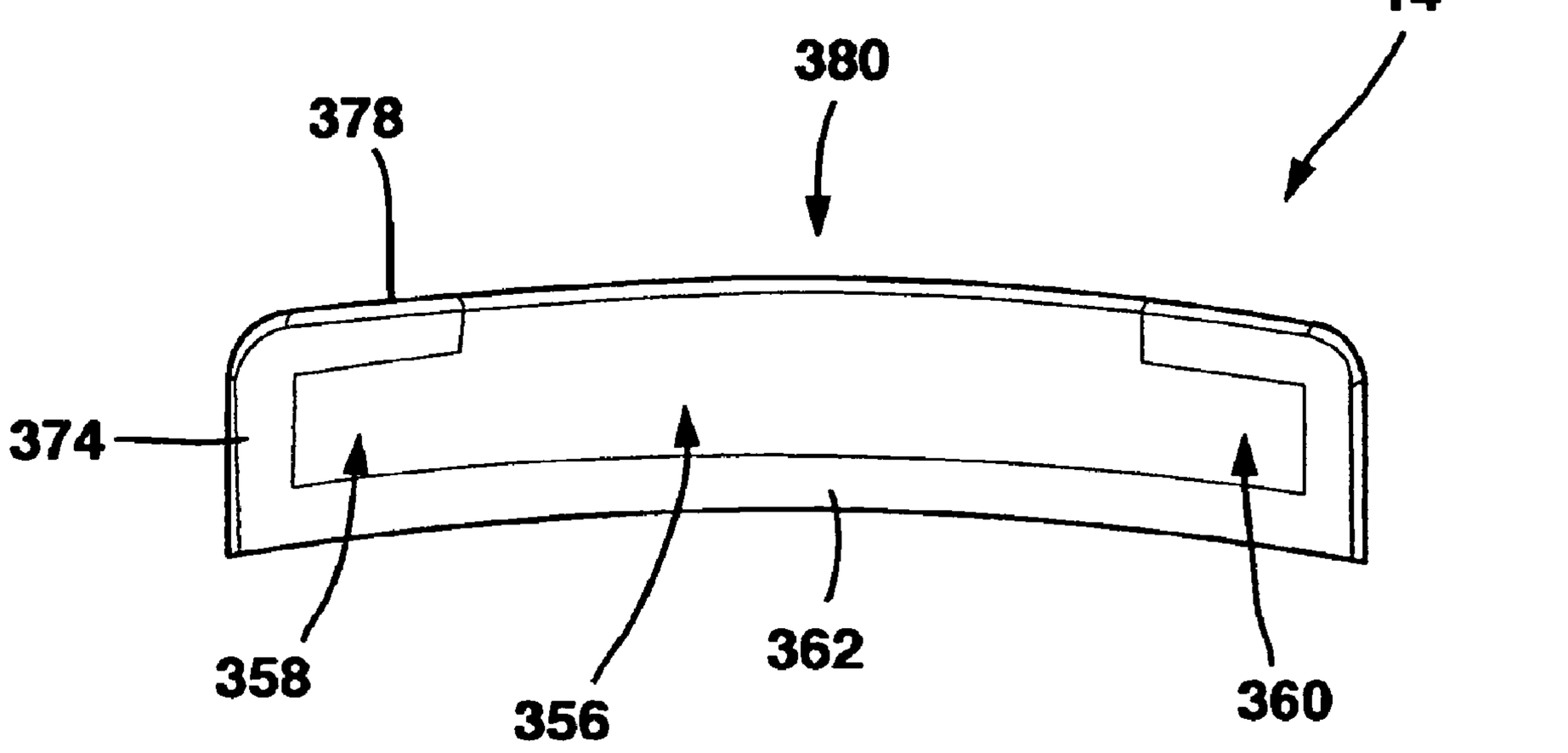
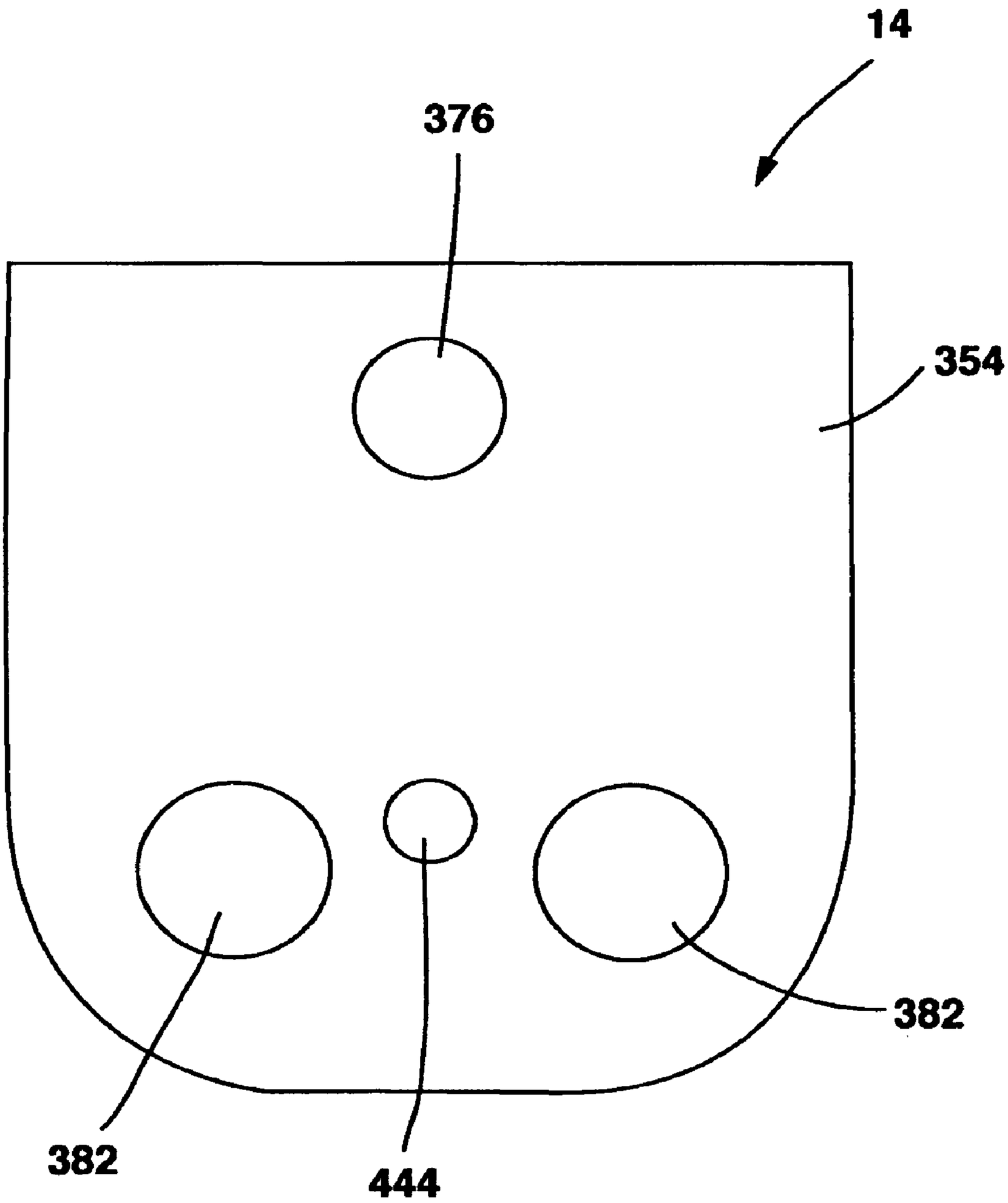


FIG. 46

FIG. 47



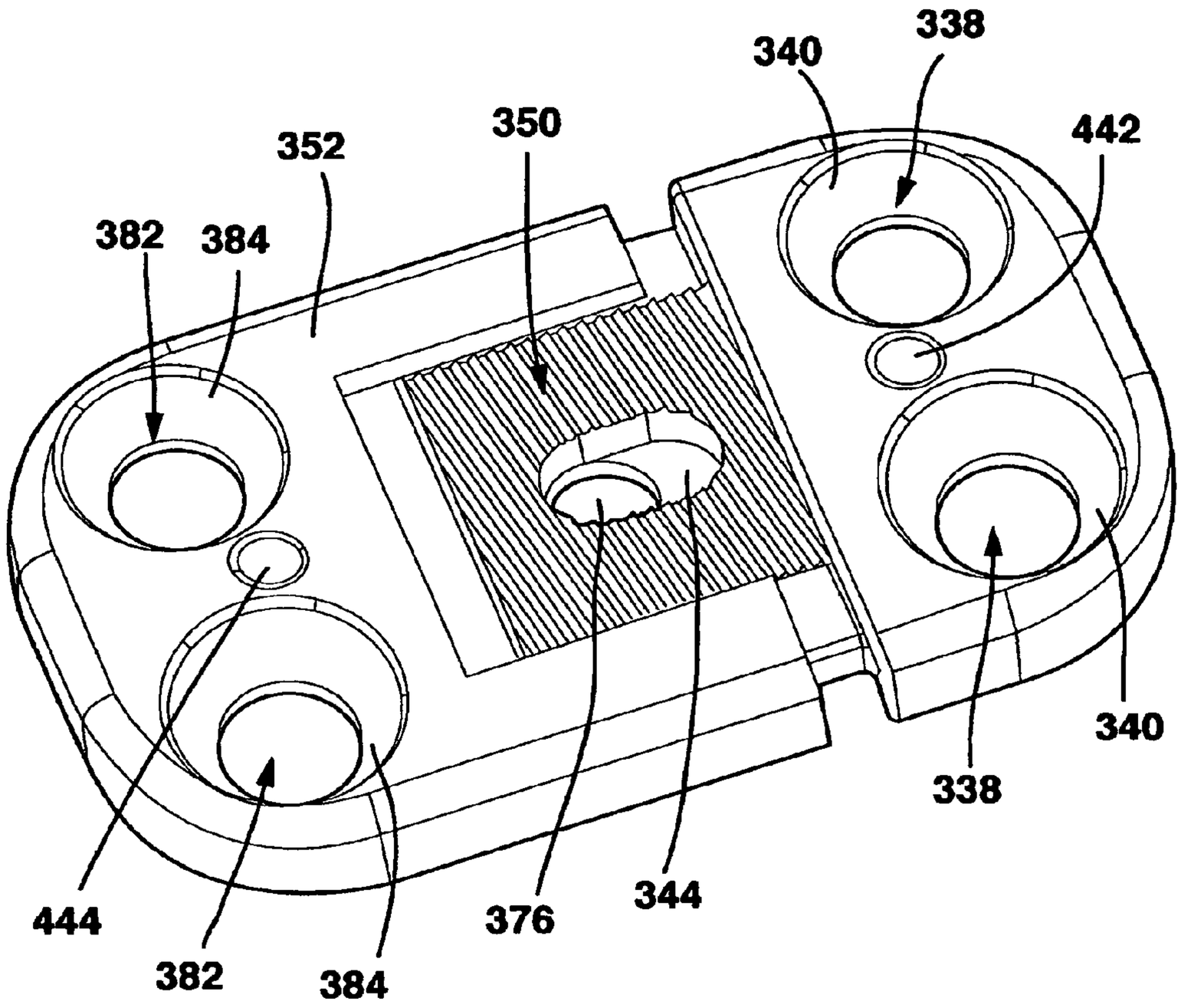


FIG. 48

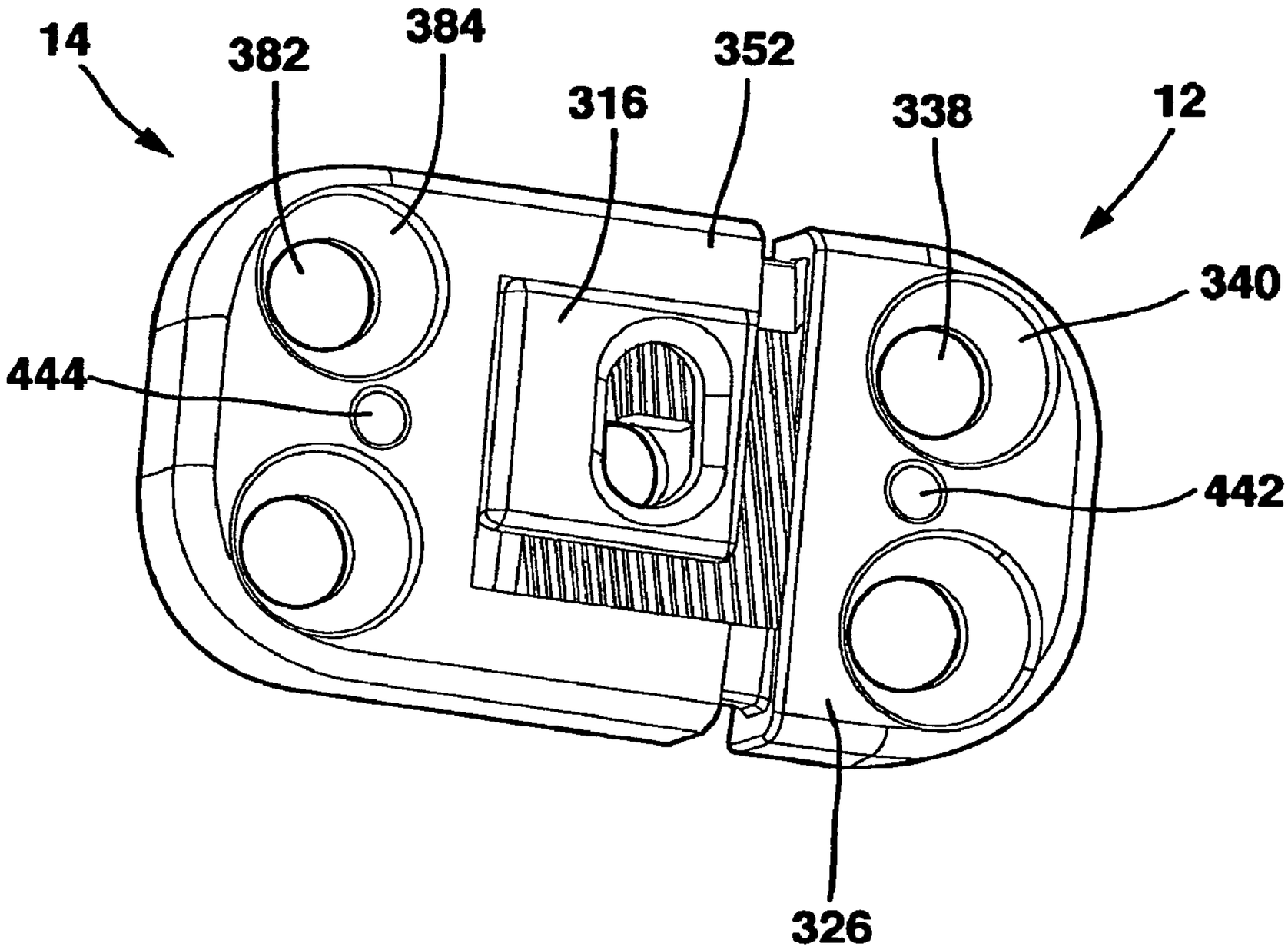


FIG. 49

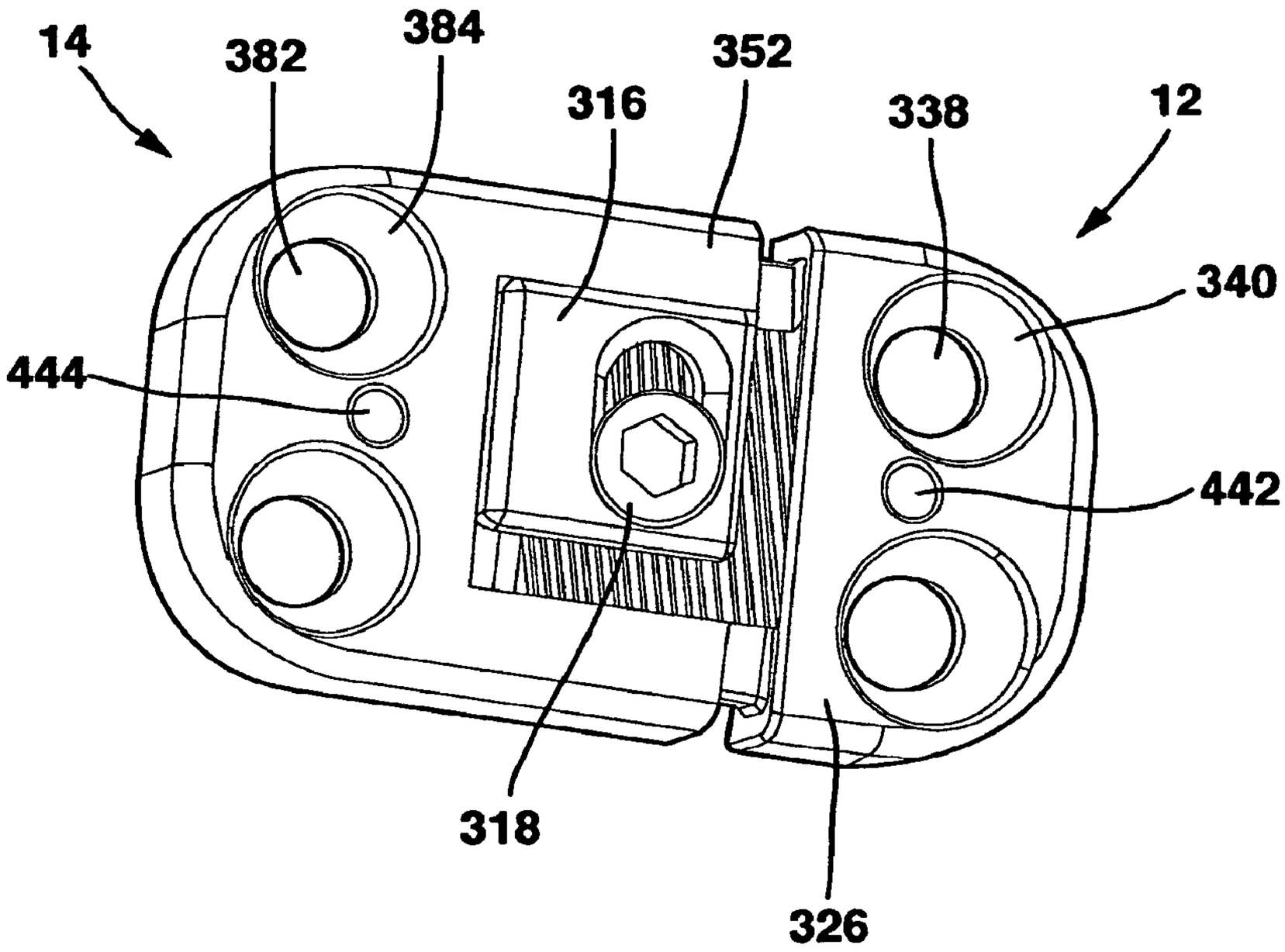


FIG. 50

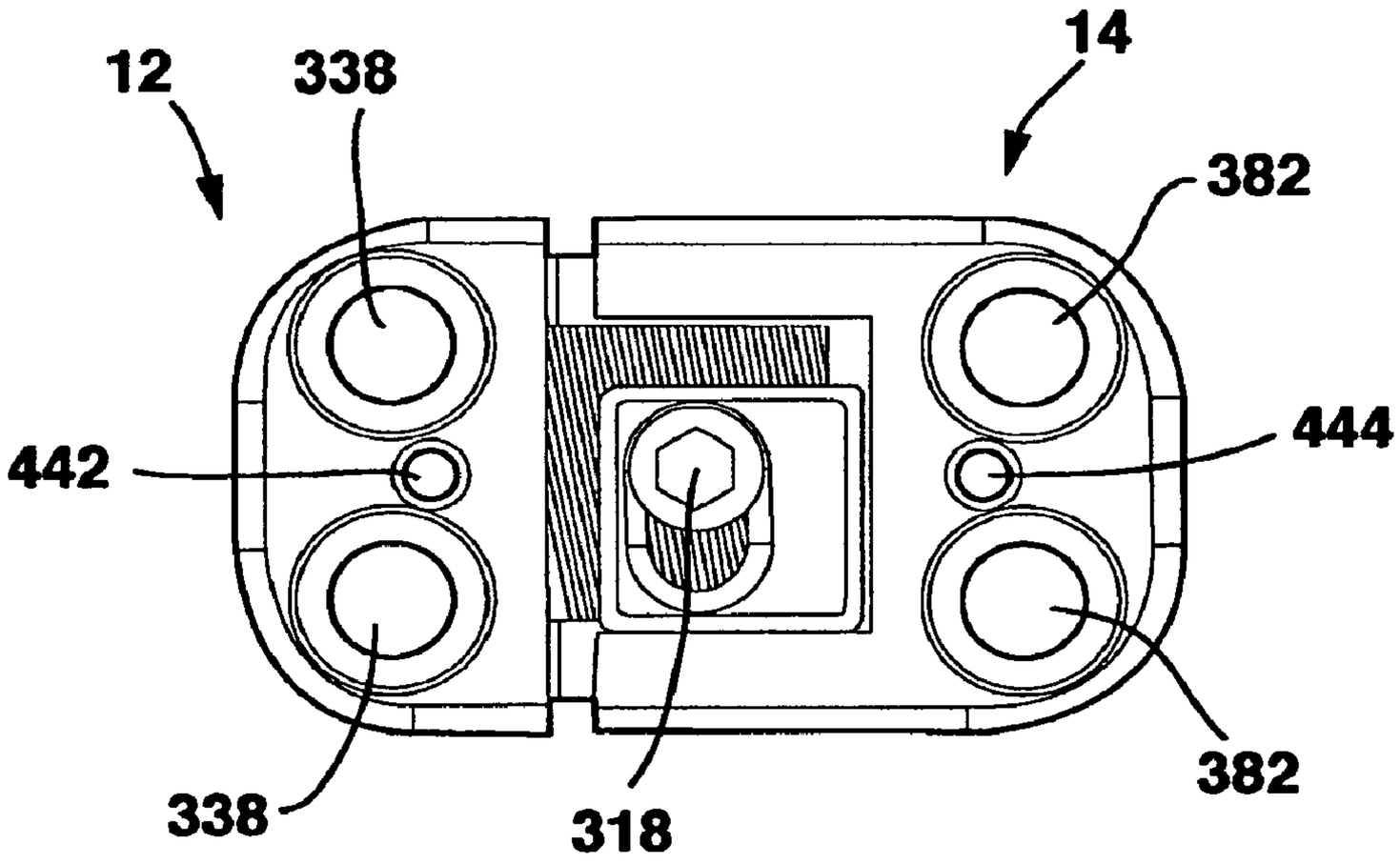

12
338
14
382
442
444
338
318
382

FIG. 51

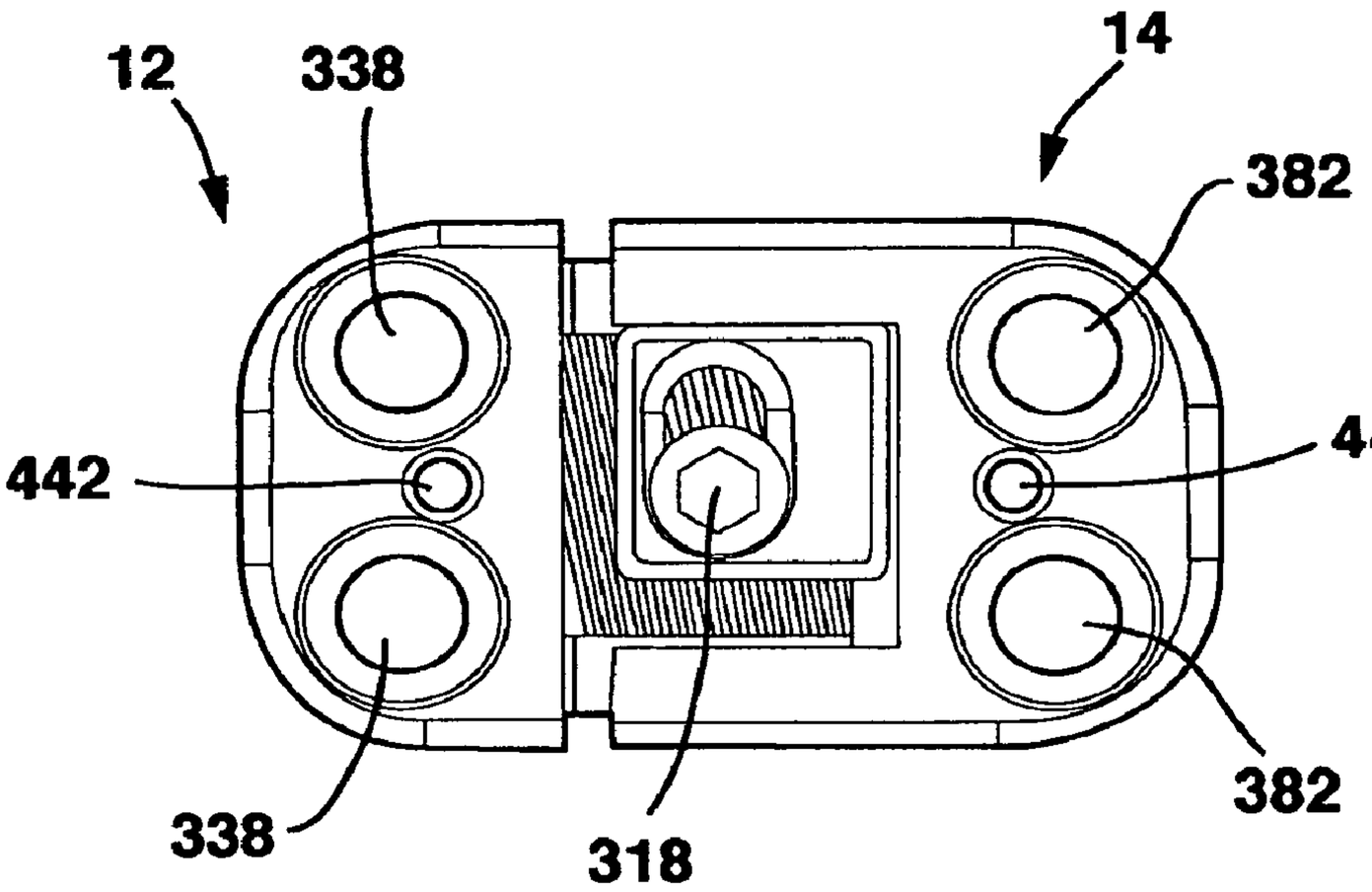

12
338
14
382
442
444
338
318
382

FIG. 52

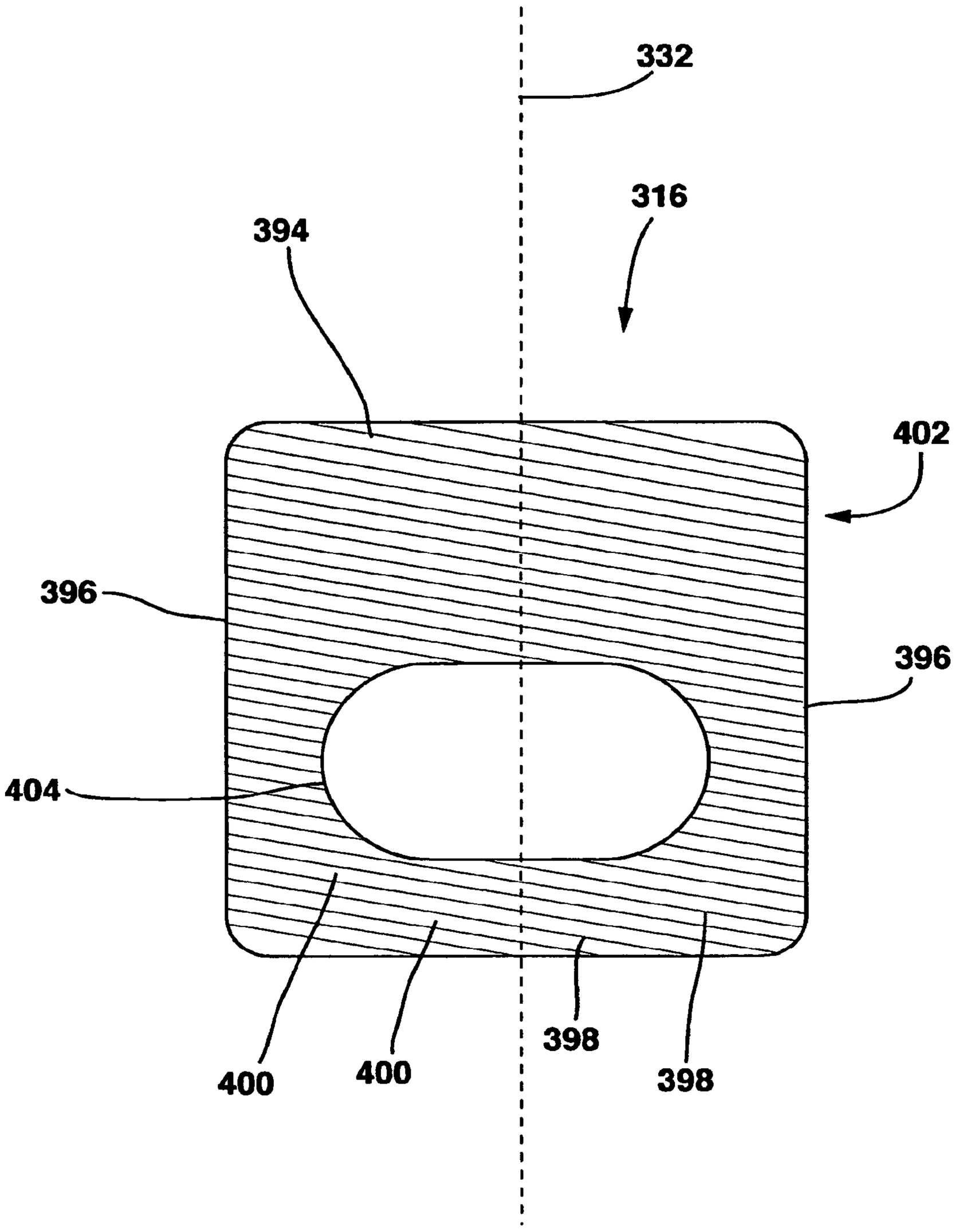


FIG. 53

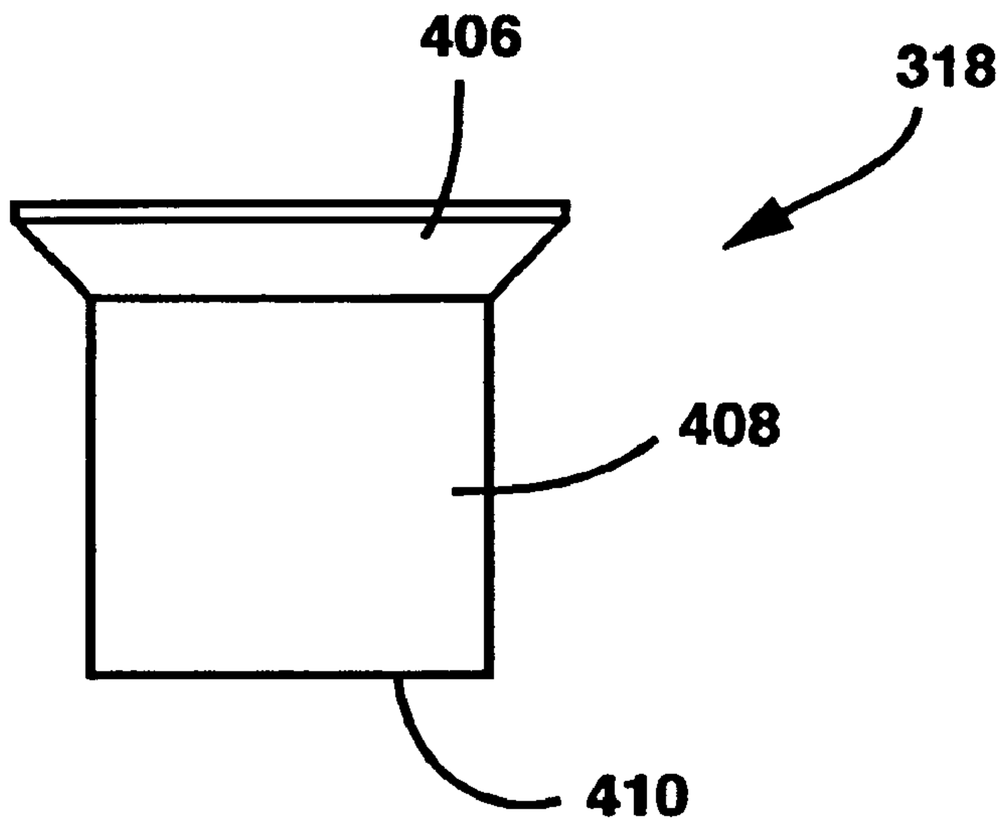


FIG. 54

FIG. 55

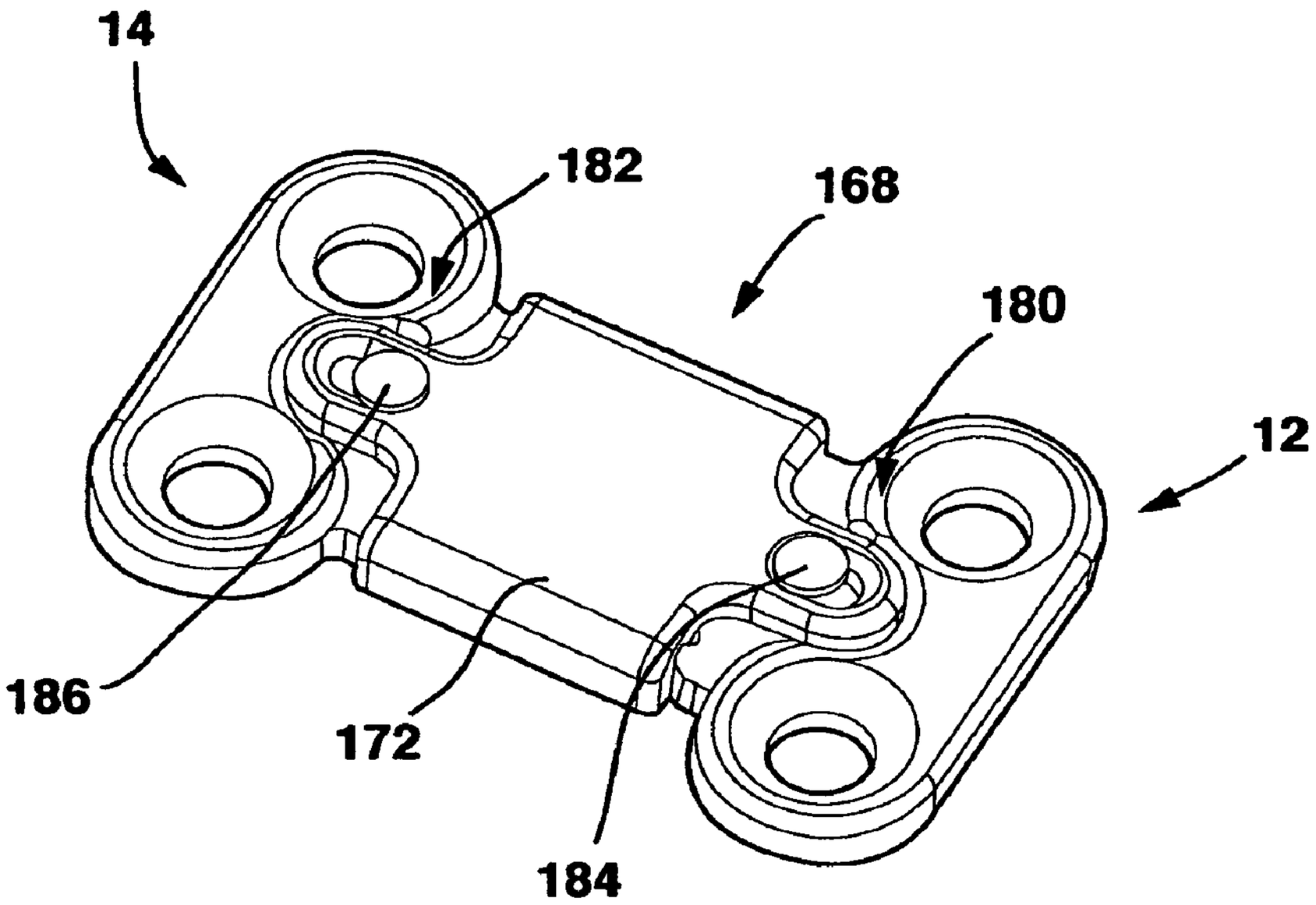
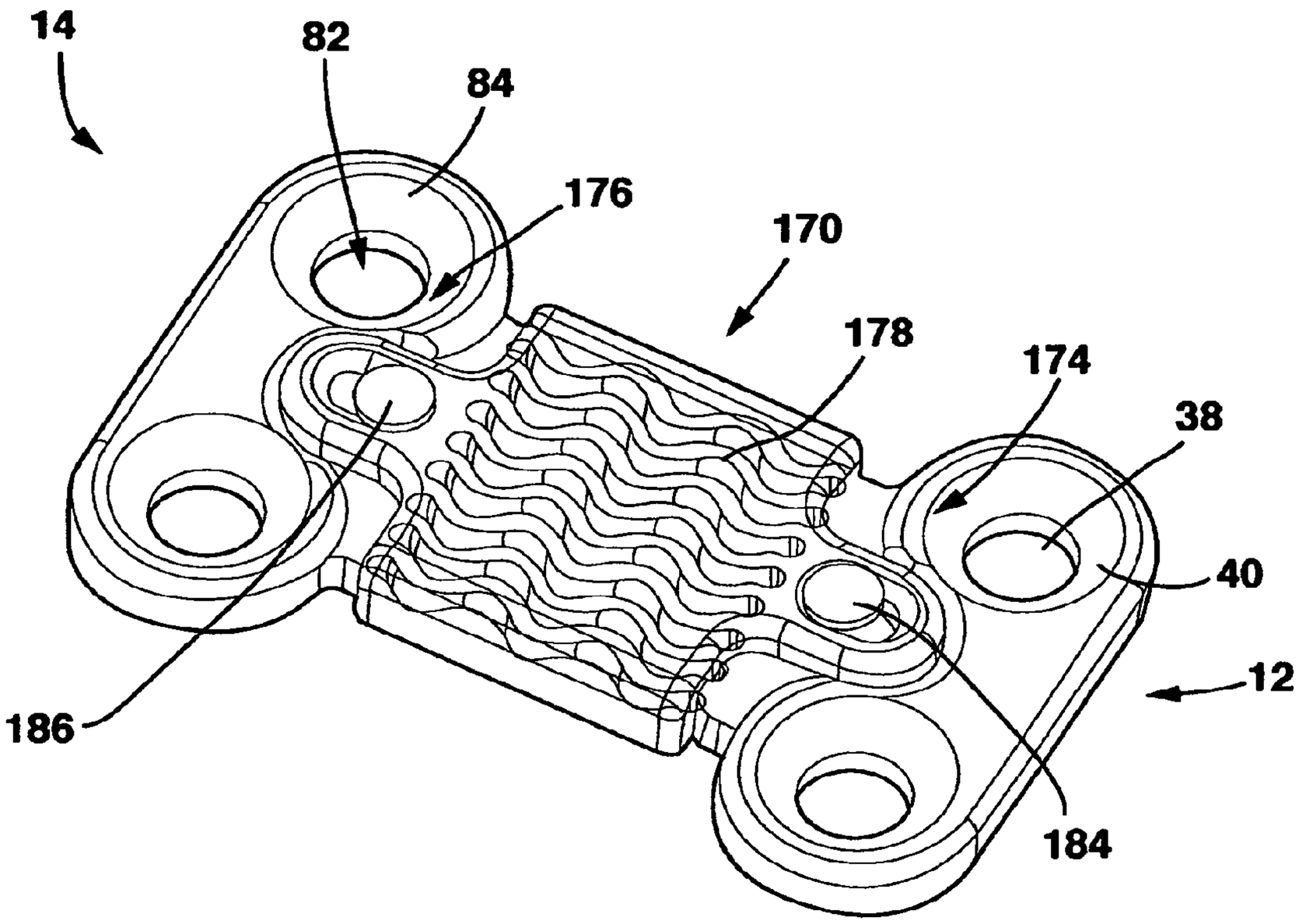


FIG. 56



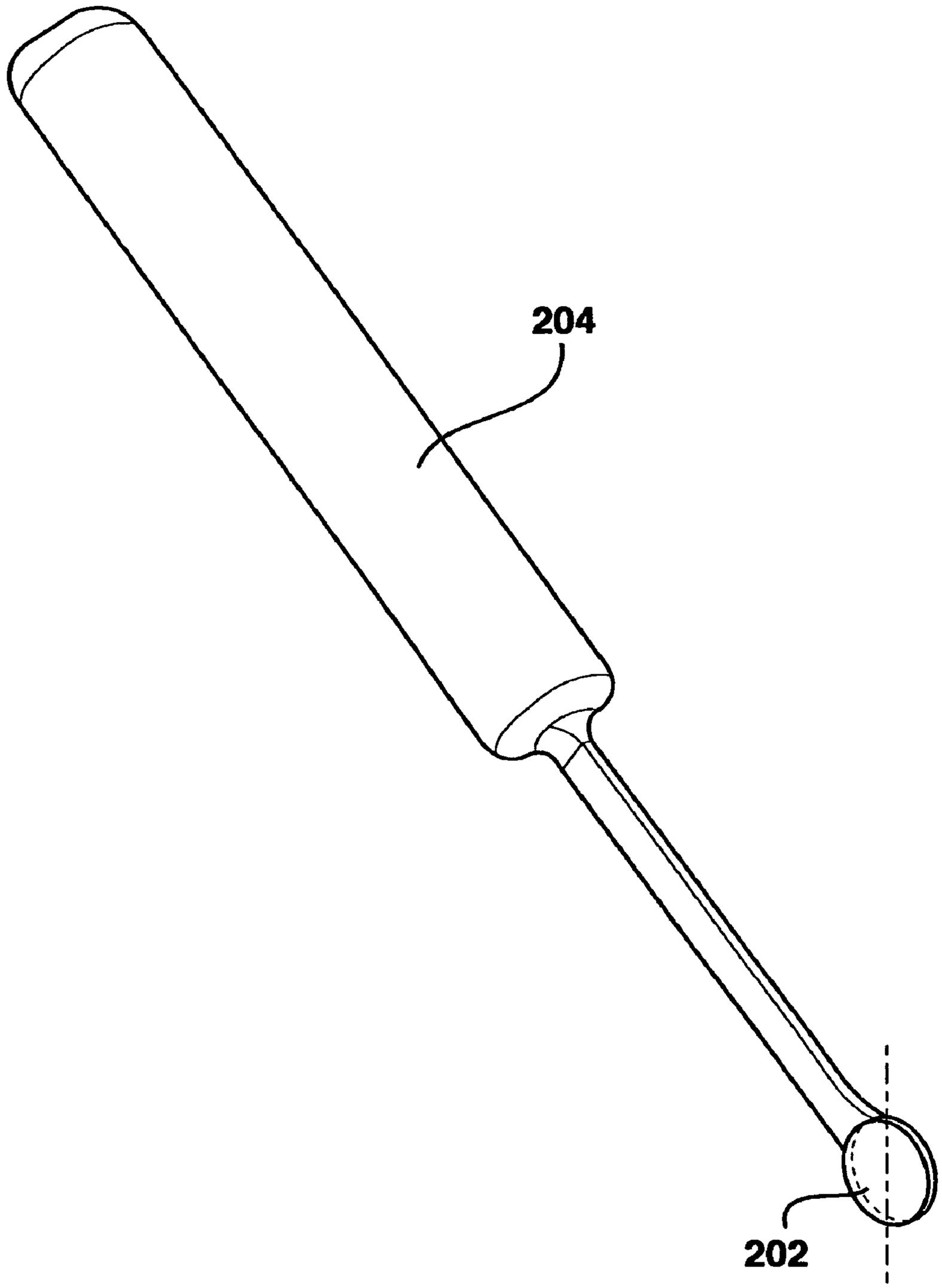


FIG. 57

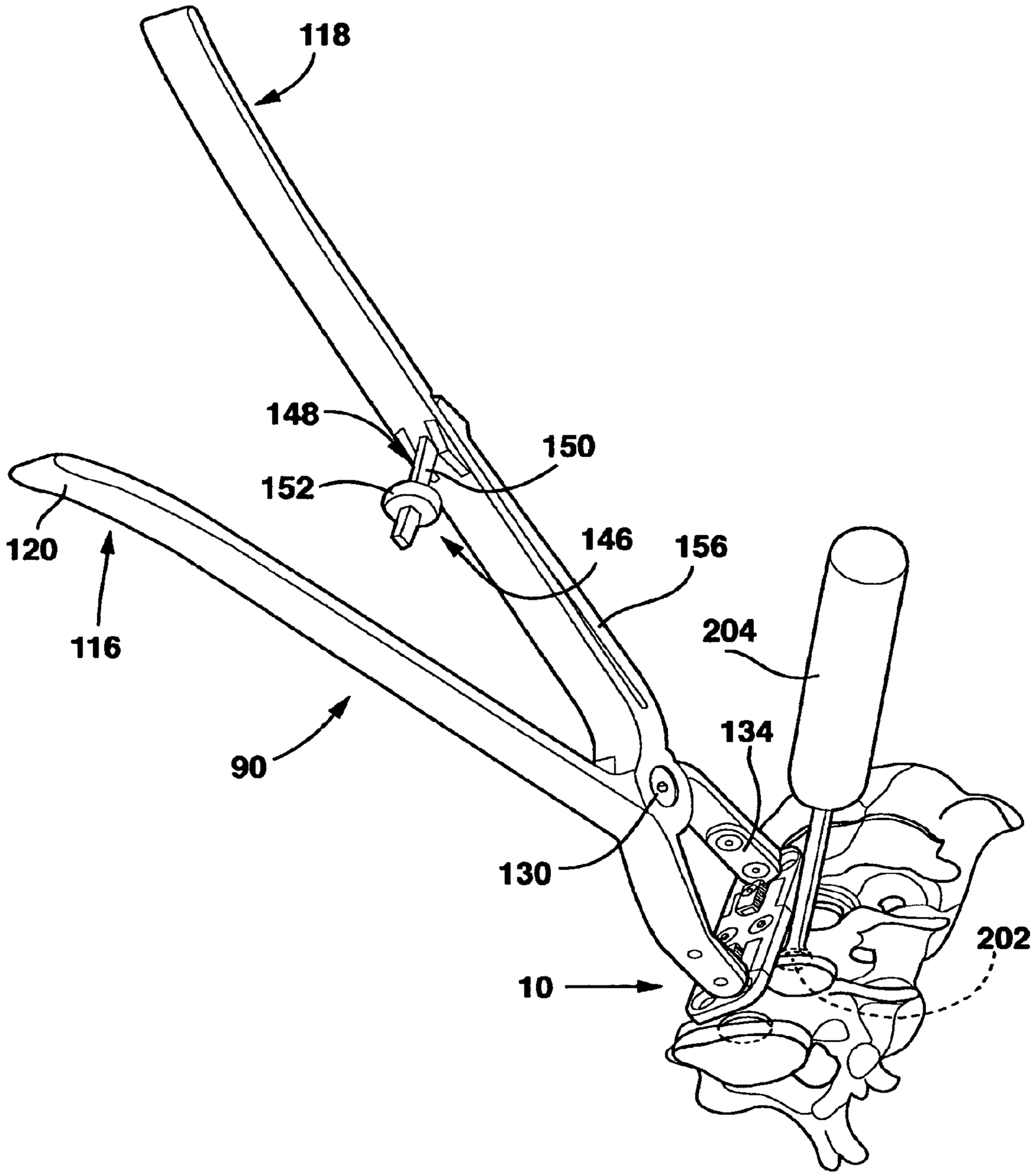


FIG. 58

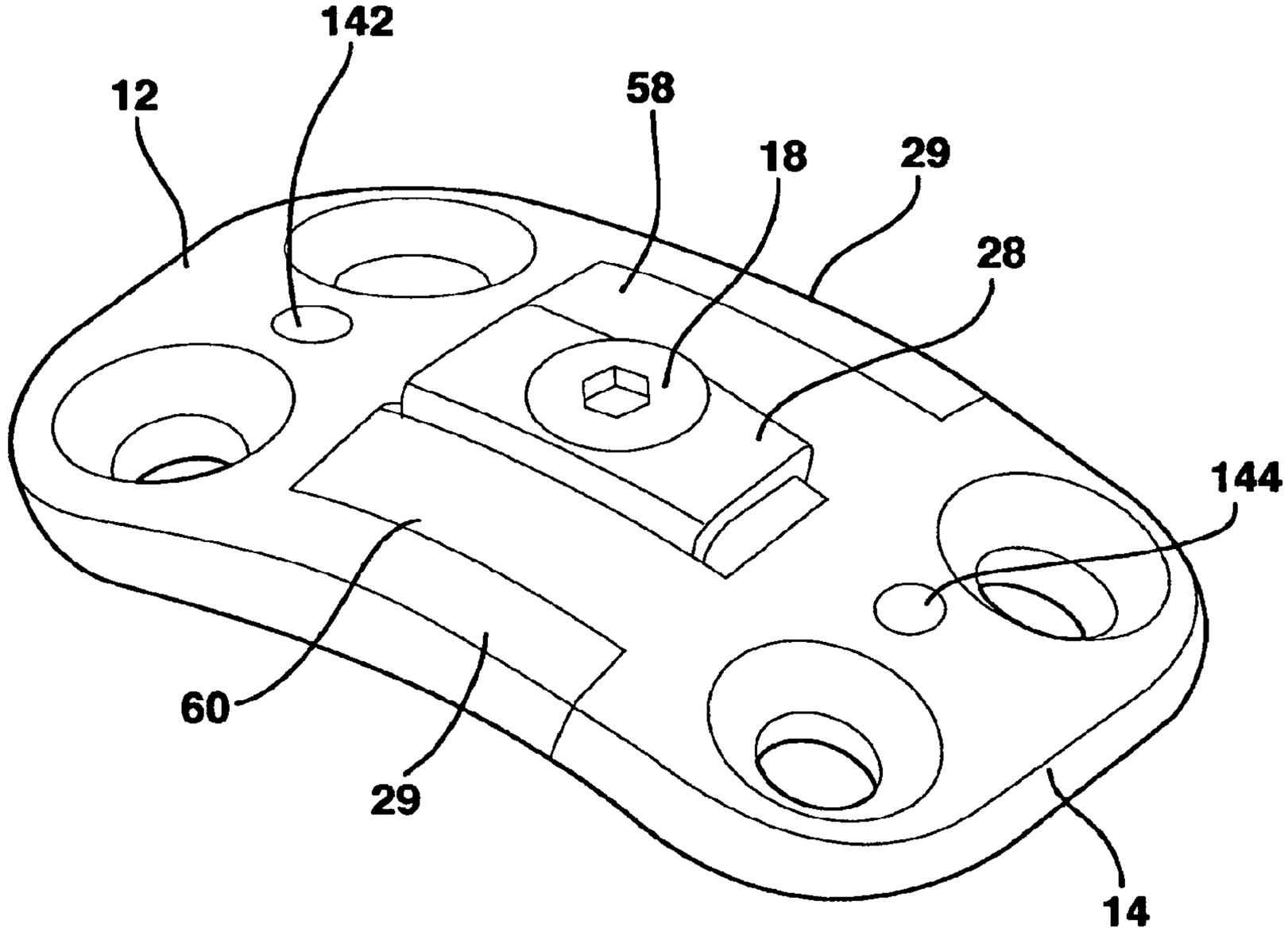


FIG. 59

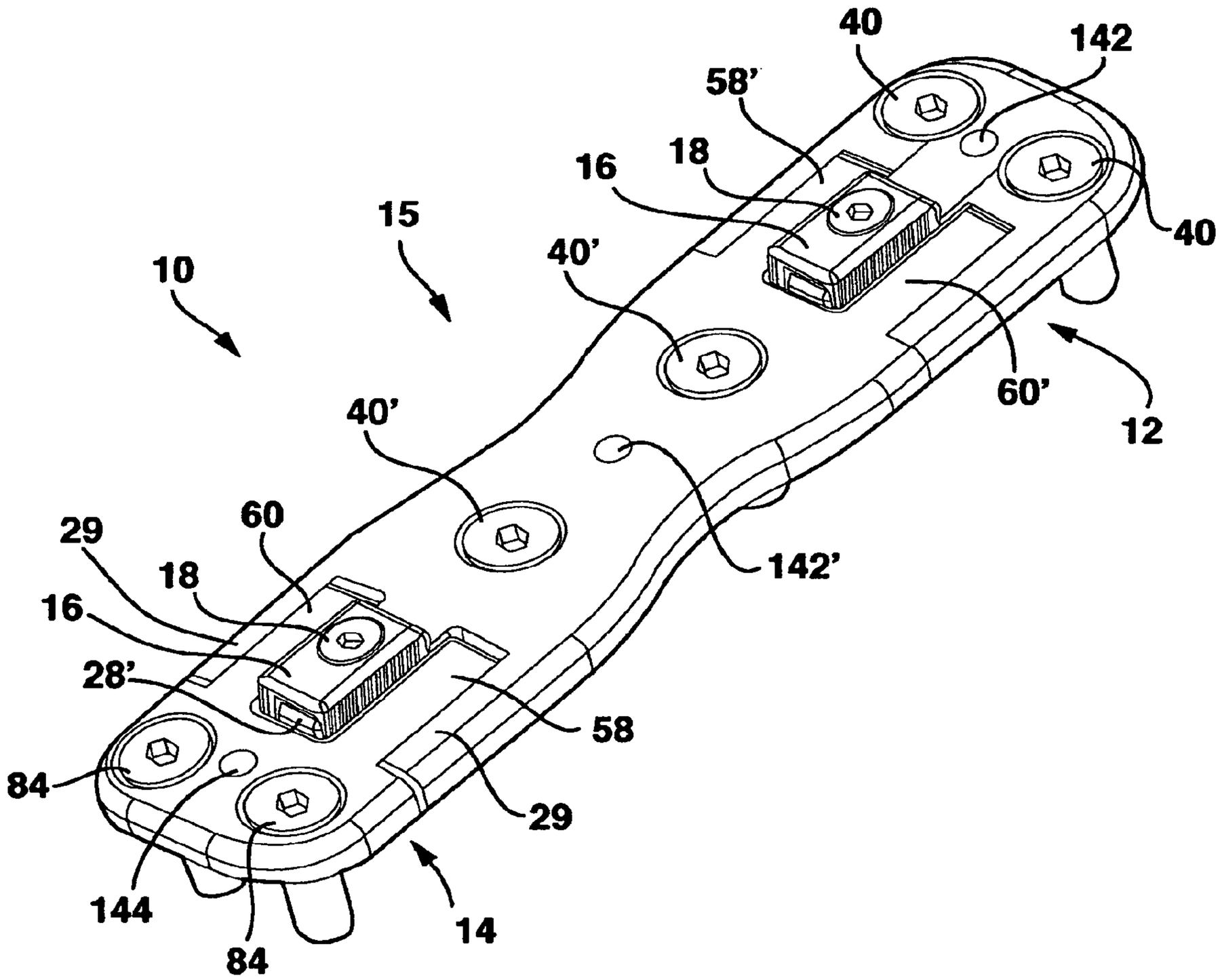

40
142
58'
18
16
15
10
40'
40
60'
12
40'
142'
60
29
18
16
28'
58
84
29
144
84
14

FIG. 60

STATIC COMPRESSION DEVICE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention is directed to devices and methods to compress two or more adjacent vertebrae across an adjacent bone graft to facilitate fusion of these vertebrae to treat pain produced by pressure from the disks between such vertebrae bulging and resulting in contact with and pressure on the spinal cord and adjacent nerve roots.

2. Description of Related Art

For nearly half a century, anterior cervical discectomy and fusion has been performed for individuals complaining of intractable upper extremity pain due to cervical disc herniation or bone spurs at single or multiple levels. This procedure has undergone several significant modifications since its inception. The introduction of the Smith-Robinson technique of using tricortical iliac crest bone graft, the technique of denuding vertebral endplates of cartilage described by Zdeblick et al., and the present use of cervical plates have all represented significant technical advances which have increased fusion rates and improved patient outcomes. Currently it is possible to expect greater than 85% good or excellent outcomes for individuals with appropriate indications who undergo this surgical procedure.

However, several problems remain. Although fusion rates for one level anterior cervical fusion with autograft (patient's own bone) may approach 95%, these rates decrease significantly for each additional level incorporated in the fusion. Additionally, using autograft bone typically involves the use of a second incision, which significantly increases patient morbidity. Allograft bone (bone from another human) is a viable option, but has considerably lower fusion rates than autograft and is generally not considered a good choice in multiple level fusion surgery.

The use of anterior cervical plates has been credited with increasing fusion rates in multiple level fusions. It is thought that the immediate stability provided by the plate provides a more favorable environment for fusion to occur. The vast majority of plates on the market provide for static stabilization of the vertebral body-graft construct (no compression, no dynamization). More recently dynamic plates have been introduced. These plates provide for passive dynamic compression of the vertebral body-graft construct. This compression occurs post-operatively when the weight of the patient's head loads the construct, allowing for passive compression of the graft to occur. Wolff's law (the concept that bone heals best under compression) suggests that the use of dynamic compression plates should lead to increased fusion rates. However, this has not been found to be the case. Several studies have indicated that dynamic compression plates do not lead to higher fusion rates than static plates. In addition, the possibility of uncontrolled settling over time which may lead to kyphosis (reversal of the normal curvature of the neck) has caused these plates to fall out of favor with many surgeons.

Wolff's law is a well-accepted orthopedic principle, championed and reported in the trauma literature by the Swiss AO Foundation, a non-profit surgeon-driven organization dedicated to progress in research, development, and education in the field of trauma and corrective surgery. Several studies have shown that long bones heal best under rigid compression.

This has led to the development of special compression plates that are currently widely used in surgical techniques of open reduction and internal fixation of fractures.

It is believed that there is no plate on the market that truly invokes Wolff's law in spinal fusion surgery by providing rigid static loading of the graft-vertebral body construct. Mechanisms for achieving compression on adjacent vertebrae are known. But, most of these devices either utilize compression across individual screws (risking cut out due to lessened surface area) or attempt to achieve compression prior to the plate being applied (making this a cumbersome technique).

SUMMARY OF THE INVENTION

The Static Compression Device (SC device) of the present invention allows for active, measurable compression of a fusion graft by the surgeon at the time of surgery. The SC device is attachable to adjacent vertebral bodies or other pieces of bone and has a device that applies compressive force to the adjacent vertebral bodies or other pieces of bone to assist fusion according to Wolff's law. The SC device has a locking mechanism that maintains the compression applied at surgery, but prevents further compression (settling) from occurring after surgery. So, the SC device allows the surgeon the ability to compress a segment or other adjacent pieces of bone, measure the applied compression, and to lock the segment or pieces of bone in the compressed position. In one embodiment of the invention, the pressure is applied to the SC device through a compression device that applies a desired and measurable amount of force. In this embodiment, the combination of the SC device with a pressure applying and measuring device allows the surgeon more control over the force applied to a cervical, lumbar or thoracic implant or implant applied to other pieces of bone than has previously been available.

The SC device of the present invention in one embodiment compresses two or more adjacent vertebrae across an adjacent bone graft to facilitate fusion of these vertebrae to treat pain produced by pressure from the disks between such vertebrae, adjacent bone spurs or both bulging and resulting in contact with and pressure on the spinal cord and adjacent nerve roots or any other disorder of the spine. The vertebrae may be in the cervical, thoracic or lumbar spine. In fact, in various embodiments, the SC device may be used to apply measurable compression across any type of bony interface (e.g. fractures) to facilitate union.

The SC device has four unique characteristics which together provide for static compression of the vertebral body-graft interface:

- The use of fixed angle screws to secure the SC device to the vertebral bodies;
- The use of a compression device to apply and measure the pressure applied to the vertebral bodies by the SC device;
- The technique of using active, static compression to assist the fusion process; and
- The use of a locking mechanism that maintains compression during the fusion process to facilitate bone growth.

This SC device differs from currently known static plates by providing controlled loading (compression) of the graft at the time of surgery. The SC device also differs from currently known dynamic plates in that the compression achieved is "static" (rigid) and prevents further "dynamic" settling from occurring after the procedure is completed. The resulting major advantage of the SC device over previously known devices is that the SC device may significantly increase fusion rates (especially in multiple level cervical fusion) and maintain the anatomy of the cervical spine (preventing excessive compression leading to kyphosis). In fact, it is believed that

using the SC device to provide static loading at each level in multiple level fusions may allow the use of allograft bone to approach fusion rates now only attainable by using autograft techniques.

The invention will be described hereafter in detail with particular reference to the drawings. Throughout this description, like elements, in whatever embodiment described, refer to common elements wherever referred to and referenced by the same reference number. The characteristics, attributes, functions, interrelations ascribed to a particular element in one location apply to that element when referred to by the same reference number in another location unless specifically stated otherwise.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of one embodiment of the static compression device of the present invention.

FIG. **2** is a top view of the static compression device of FIG. **1**.

FIG. **3** is a bottom view of the static compression device of FIG. **1**.

FIG. **4** is a side view of the static compression device of FIG. **1**.

FIG. **5** is a bottom end view of the static compression device of FIG. **1**.

FIG. **6** is a perspective view of the male plate of the static compression device of FIG. **1**.

FIG. **7** is a side view of the male plate of the static compression device of FIG. **1**.

FIG. **8** is a top view of the male plate of the static compression device of FIG. **1**.

FIG. **9** is a bottom end view of the male plate of the static compression device of FIG. **1**.

FIG. **10** is a perspective view of the female plate of the static compression device of FIG. **1**.

FIG. **11** is an end view of the female plate of the static compression device of FIG. **1**.

FIG. **12** is a bottom view of the female plate of the static compression device of FIG. **1**.

FIG. **13** is a perspective view of the interconnecting plate of the static compression device of FIG. **1**

FIG. **14** is a top view of the interconnecting plate of the static compression device of FIG. **1**.

FIG. **15** is a perspective view of the static compression device of FIG. **1** in an embodiment without the interconnecting plate.

FIG. **16** is a perspective view of the static compression device of FIG. **15** in an unlocked configuration.

FIG. **17** is a perspective view of the static compression device of FIG. **15** in a locked configuration.

FIG. **18** is a perspective view of the locking clamp of the static compression device of FIGS. **1** and **15**.

FIG. **19** is a side view of the locking screw of the static compression device of FIG. **1**.

FIG. **20** is a perspective view of one embodiment of the compression tool of the present invention.

FIG. **21** is a perspective view of the embodiment of the compression tool of FIG. **20** from the opposite side of the view of FIG. **20**.

FIG. **22** is a perspective view of the preferred embodiment of the compression tool of the present invention with cannula for receiving a screwdriver.

FIG. **23** is a close up perspective view of the distal end of the compression tools of the present invention.

FIG. **24** is a perspective view of another embodiment of the compression tool of the present invention.

FIG. **25** is a side view of the embodiment of the compression tool of FIG. **24**.

FIG. **26** is an exploded perspective view of the turnbuckle of the embodiment of the compression tool of FIG. **24**.

FIG. **27** is an exploded perspective view of the compression tool of FIG. **24**.

FIG. **28** is a perspective view of an embodiment of the static compression device of the present invention.

FIG. **29** is a perspective view of the static compression device of FIG. **28** without the locking screw in place.

FIG. **30** is a side view of the locking screw of the static compression device of FIG. **28**.

FIG. **31** is a cross-sectional perspective view of the static compression device of FIG. **28** without the locking screw in place.

FIG. **32** is a perspective view of the static compression device of FIG. **28** without an alternate embodiment of the locking screw in place.

FIG. **33** is a perspective view of an alternate embodiment of the static compression device.

FIG. **34** is an end view of the female plate of the static compression device of FIG. **33** with the locking screw and cam in place.

FIG. **35** is a perspective view of the locking screw and cam of the static compression device of FIG. **33**.

FIG. **36** is a perspective view of one embodiment of the static compression device of the present invention.

FIG. **37** is a top view of the static compression device of FIG. **36**.

FIG. **38** is a bottom view of the static compression device of FIG. **36**.

FIG. **39** is a side view of the static compression device of FIG. **36**.

FIG. **40** is a bottom end view of the static compression device of FIG. **36**.

FIG. **41** is a top end view of the static compression device of FIG. **36**.

FIG. **42** is a perspective view of the male plate of the static compression device of FIG. **36**.

FIG. **43** is a side view of the male plate of the static compression device of FIG. **36**.

FIG. **44** is a bottom view of the male plate of the static compression device of FIG. **36**.

FIG. **45** is a perspective view of the female plate of the static compression device of FIG. **36**.

FIG. **46** is an end view of the female plate of the static compression device of FIG. **36**.

FIG. **47** is a bottom view of the female plate of the static compression device of FIG. **36**.

FIG. **48** is a perspective view of the male plate and female plate of the static compression device of FIG. **36** in an interconnected relationship.

FIG. **49** is a perspective view of the male plate and female plate of the static compression device of FIG. **36** in an interconnected relationship and with the locking plate in place.

FIG. **50** is a perspective view of the male plate and female plate of the static compression device of FIG. **36** in an interconnected relationship and with the locking plate and locking screw in place.

FIG. **51** is a top view of the static compression device of FIG. **36** with the male plate interconnected to the female plate and with the locking plate in place and in the uncompressed position.

FIG. **52** is a top view of the static compression device of FIG. **36** with the male plate interconnected to the female plate and with the locking plate in place and in the compressed position.

FIG. **53** is a bottom view of the locking plate of the static compression device of FIG. **36**.

FIG. **54** is a side view of the locking screw of the static compression device of FIG. **36**.

FIG. **55** is a perspective view of an alternate embodiment of the static compression device.

FIG. **56** is a perspective view of the static compression device of FIG. **55** with the guide plate shown in phantom.

FIG. **57** is a perspective view of a series of trial spacers and corresponding handle of one aspect of the present invention.

FIG. **58** is a perspective view of an embodiment of the static compression device designed to be used in the thoracic or lumbar region of the spine.

FIG. **59** is a perspective view of an embodiment of the static compression device designed to be used to treat fractures.

DETAILED DESCRIPTION OF THE INVENTION

The SC device **10** in a preferred embodiment shown in FIGS. **1-14** and **18** has five main parts, a male plate **12**, a female plate **14**, an interconnecting plate **15**, a locking clamp **16** and a locking screw **18** that, in combination with standard cancellous bone screws (not shown) fix the SC device **10** to the patient's vertebrae. The SC device **10** has a top side **20**, a bottom side **22** and opposed medial sides **24**.

The male plate **12** has a male main body **26** and a central protrusion **28** extending away from the male main body **26**. The central protrusion **28** has a top surface **30**, a longitudinal axis **32**, a bottom surface **33** and parallel sides **36**. Central protrusion **28** also has a threaded hole **35** in the top surface **30**.

The male plate **12** also has a pair of side protrusions **29** extending away from the male main body **26** on opposite sides of the central protrusion **28**. Each of the side protrusions **29** has an inner surface **37** and an outer surface **39**. The inner surfaces **37** are directed toward the central protrusion **28** and are preferably curved in a concave fashion to mate with the outer surfaces **63** of the left guide **58** and right guide **60** of the interconnecting plate **15** or the female plate **14** as will be described hereafter.

The male main body **26** is relatively flat with a top side **34** and a bottom side **36** and, in a preferred embodiment, has two screw receiving holes **38**. The screw receiving holes **38** each have a bowl-shaped basin **40** on the top side **34** to receive the heads of the screws **43** and a throughhole **42** through which the main body of the screws **43** pass to come into contact with the vertebral body. The throughholes **42** are configured in a manner that allows the cancellous bone screws **43** to be rigidly fixed to the plate once inserted in bone. The method of fixing the screws **43** to the plate may utilize any number of mechanisms well understood in the art that allow the screws **43** and the male plate **12** to maintain a rigid relationship once the screws **43** are inserted in bone.

The bottom side **36** of the male plate **12**, female plate **14** and interconnecting plate **15** is preferable roughened, thereby allowing the bottom side **22** of the SC device **10** to "grip" the vertebral body when the bottom side **22** of the SC device **10** is brought into contact with and secured to the vertebral body by the interaction of the screws **43** and the body of the SC device **10** as described herein.

As mentioned, the male plate **12** has a central protrusion **28** with a top surface **30** and a longitudinal axis **32**. Central protrusion **28** is dimensioned to mate with and secure the male plate **12** with the interconnecting plate **15** or the female plate **14** as will be described in detail hereafter. Where the interconnecting plate **15** is used, the combined length of the central protrusion **28** on the male plate **12** and the central protrusion **28'** on the interconnecting plate **15** will be slightly longer than the distance the SC device **10** in intended to provide compression over.

Central protrusion **28** has a boss **44** extending entirely through it approximately parallel to the top surface **30** that is designed to mate with a relief cut **62** in the interconnecting plate **15**/female plate **14**.

The interconnecting plate **15** combines the features of the male plate **12** and the female plate **14** on its opposite ends. As a result, on one end of interconnecting plate there is a central protrusion **28'** essentially as described in connection with the central protrusion **28** of male plate **12**. On the opposite end of interconnection plate **15**, there is a protrusion receiving channel **56** essentially as described hereafter in connection with the protrusion receiving channel **56** of female plate **14**. In addition, interconnecting plate **15** has at least a pair of screw receiving holes **38** essentially as described in connection with the screw receiving holes **38** of the male plate **12**.

The purpose of the interconnecting plate **15** is to allow the SC device **10** to be secured to three or more adjacent vertebrae and allow the SC device **10** to apply compression across these vertebrae to facilitate healing as described herein. As a result, a single interconnecting plate **15** may be placed between the male plate **12** and the female plate **14** and attached to the vertebra between the vertebrae that the male and females plates **12**, **14** are attached to. Alternately, several interconnecting plates **15** can be connected end to end (i.e., the protrusion receiving channel **56** of one interconnecting plate **15** receives the central protrusion **28'** of an adjacent interconnecting plate **15** and the process continues until all the interconnecting plates **15** are joined together) to form an interconnecting span with a male plate **12** and a female plate **14** attached to the ultimate ends of this chain of interconnecting plates **15**. In this embodiment of the invention, each of the interconnecting plates **15** would have screw receiving holes **38** allowing each interconnecting plate **15** to be attached to a single vertebra by bone screws **43**. In a variant of this embodiment, a single interconnecting plate **15** could have several sets of screw receiving holes **38** so that this single interconnecting plate **15** could be attached to several adjacent vertebrae or could span a previously fused segment.

The female plate **14** has a female main body **52** with a bottom side **54** and a protrusion receiving channel **56**. Protrusion receiving channel **56** is formed between a left guide **58** and a right guide **60** that extend away from the female main body **52**. Left guide **58** and right guide **60** each have an inner surface **61**, an outer surface **63**, a bottom surface **65** and a top surface **67**. Left guide **58** and right guide **60** are basically rectangular in cross-section with inner surfaces **61** being preferably essentially planar and with outer surfaces **63** being essentially outwardly curved with a series of ridges **71** extending outwardly. On the bottom surface **65** of the left and right guides **58**, **60** facing the protrusion receiving channel **56**, there is a relief cut **62** machined to accept the boss **44** on the central protrusion **28'** of the interconnecting plate **15** or the male plate **14**.

Protrusion receiving channel **56** is dimensioned to snugly receive the central protrusion **28'** with the locking clamp **16** in place on the central protrusion **28'** as will be described hereafter so that the central protrusion **28'** is "captured" and held in the protrusion receiving channel **56** by physical contact between the outer surface of the locking clamp **16** and the inner surfaces of the left guide **58** and right guide **60** as well as by the interaction between the central protrusion **28'** and the boss **44** on the inferior aspect of the central protrusion **28'** and relief cut **62**.

The outer surfaces **63** of the left and right guides **58**, **60** contact the inner surfaces **37** of the side protrusions **29** under the influence of the locking clamp **16**, as will be described hereafter, to securely locate the female plate **14** with respect to the interconnecting plate **15** and the interconnecting plate **15** with the male plate **12**.

The female plate **14**, also in a preferred embodiment, has two screw receiving holes **82**. These screw receiving holes **82** receive standard cancellous bone screws **43** that are threaded into the bone of the vertebrae. In similar fashion to screw receiving holes **38**, the screw receiving holes **82** also have a bowl-shaped basin **84** on the upper surface **78** to receive the heads of the bone screws **43** and a throughhole **86** through which the main body of the bone screws **43** pass to come into contact with the vertebral body. The throughholes **86** are configured in a manner that allows the cancellous bone screws **43** to be rigidly fixed to the plate once inserted in bone by the interaction of the screws **43** with the basins **84**. The method of fixing the screws **43** to the female plate **14** may utilize any number of mechanisms well understood in the art that allow the screws **43** and the female plate **14** to maintain a rigid relationship once the screws **43** are inserted in bone.

The SC device **10** has a locking mechanism **88**. Locking mechanism **88** converts "active" compression applied by the surgeon using the compression device **90** described below interacting with the device **10** at the time of surgery to "static" compression after surgery. The locking mechanism **88** also provides rigid fixation to the SC device **10** to optimize bone healing and preventing further settling from occurring.

The locking mechanism **88** in one embodiment includes locking clamp **16** and locking screw **18**. The locking clamp **16** has a top surface **92** with a hole **93** extending through it, a bottom surface **94**, parallel sides **96**, a longitudinal axis **97** and an inner channel **99** between the parallel sides **96** and below the top surface **92**. The inner width of the inner channel **99** of the locking clamp **16** (i.e., the inside distance between the parallel sides **96**) is such that the locking clamp **16** will fit snugly over the central protrusion **28**. The width of the locking clamp **16** (i.e., the distance between the parallel sides **96**) is such that the locking clamp **16** will fit snugly between the left and right guides **58**, **60** in the protrusion receiving channel **56**.

A single large locking screw **18**, dimensioned to rotate freely within the hole **93** of the locking clamp **16**, activates the locking mechanism **88**. In the embodiment of the invention shown in FIGS. **1-19**, the locking screw **18** has a head **106**, a body **108** and a distal end **110** opposite the head **106**. The head **106** has a larger cross-sectional diameter than the threaded body **108**. The body **108** is threaded at least on the distal end **110** to correspond to the threads of the threaded hole **35** in the protrusion **28**.

The parallel sides **96** of locking clamp **16** preferably have a series of ridges **46** and valleys **48**, preferably placed substantially perpendicular to the longitudinal axis **97** and tapered from top to bottom, to locate and affix the locking clamp **16** to the inner surfaces of the left guide **58** and right guide **60** of the interconnecting plate **15** and female plate **14**. Through this configuration, the ridges **46** and valleys **48** on the sides **96** of the locking clamp **16** preferably contact and engage with the inner surfaces of left and right guides **58**, **60** in frictional or mechanical contact to precisely locate and affix the locking clamp **16** within the protrusion receiving channel **56**. Because the series of ridges **46** and **48** are tapered, as the series of ridges **46**, **48** are moved into contact with and engage the inner surfaces of left and right guides **58**, **60**, this engagement adds compressive force to the adjacent vertebral bodies through the SC device **10**. The locking clamp **16** is preferably made of a material that is harder than the material of the interconnecting plate **15** or the female plate **14**.

The present invention also includes a compression device **90** (FIGS. **20-23**) that allows the surgeon to provide active, controlled compression between the two sliding components of the SC device **10** (male plate **12** and female plate **14**) at the time of surgery. This compression device **90** allows the surgeon to accurately measure the force applied across the graft by the SC device **10** and allows the surgeon to stop compressing when a predetermined amount of force has been obtained. Since both the male plate **12** and the female plate **14** are each connected to adjacent vertebral bodies by two fixed angle bone screws **43**, this provides for even, surgeon-controlled compression across the interbody graft.

The compression device **90** has two arms **114**, **116** that each have a handle **118**, **120** at one end and a foot **122**, **124**, located at a distal end **126**, **128**, respectively. The arms **114**, **116** are connected via a pivot **130** that connects the respective arms **114**, **116** and allows them to move in scissors-like movement with respect to each other. By connecting the arms **114**, **116** through a pivot **130**, a surgeon squeezing the handles **118**, **120** moves the distal ends **126**, **128** together. By connecting these distal ends **126**, **128** to the device **10**, a surgeon squeezing the handles **118**, **120** together is able to apply compression to the SC device **10** and thus to adjacent vertebral bodies through the interaction of the feet **122**, **124** and the male plate **12** and female plate **14** as will be explained hereafter.

Each foot **122**, **124** of the compression device **90** engages the male plate **12** or female plate **14** (or interconnecting plate **15**), respectively, to apply pressure to move the male plate **12** and female plate **14** toward each other as the physician squeezes the handles **118**, **120** together. In the embodiment of compression device **90** and SC device **10** shown in FIG. **23**, the distal ends **126**, **128** of feet **122**, **124**, respectively, are shaped with pins **132** that protrude from the distal ends **126**, **128**.

In the embodiment shown in FIGS. **21-23**, pins **132** protrude from adaptor plates **134** having throughholes **136**. Adaptor plates **134** are secured to the distal ends **126**, **128** of feet **122**, **124**, respectively by screws **138** that pass through throughholes **136**. The distal ends **126**, **128** of feet **122**, **124**, respectively each have a threaded secure hole **140** that receives a screw **138**. In this way, adaptor plates **134** are secured to the distal ends **126**, **128** of feet **122**, **124**, respectively. The adaptor plates **134** may be removed and replaced with hooks protruding from the distal ends **126**, **128** of feet **122**, **124**, respectively, that each engage a slot on the outermost aspects of the male and female plates **12**, **14** placed or formed in the top side **34** of the male plate **12** and the top surface **78** of the female plate **14**. This enables the ends of compression device **90** to be modular (i.e., replaceable so that the appropriate end for a desired application can be placed on the compression device **90**) with respect to using different techniques to achieve compression.

The male plate **12** and female plate **14** each have a notch **142**, **144**, respectively, located on opposite ends of the SC device **10** and shaped to receive the pins **132** in a snug, conforming fashion so that compression applied to the feet **122**, **124** by squeezing the handles **118**, **120** together is transferred from the distal ends **126**, **128** to the male plate **12** and female plate **14**, respectively, through the interaction of the pins **132** with the notches **142**, **144**.

In an alternate embodiment of the invention, the distal ends **126**, **128** of feet **122**, **124**, respectively, again engage the male plate **12** and the female plate **14**, respectively, through pins **132**. However, in this embodiment, the notches **142**, **144** are located in the outer edge of the top surfaces **26** and upper

surface **78** of the male plate **12** and female plate **14**, respectively, sized and shaped to receive the pins **132** in a snug fashion so that compression applied to the feet **122**, **124** by squeezing the handles **118**, **120** together is transferred from the pins **132** to the male plate **12** and female plate **14**, respectively, through the notches **142**, **144**.

The compression device **90** also preferably has a gauge **146** that allows the physician to measure the compression force being applied to the SC device **10**, and thus to the vertebral bodies, by the squeezing together of the handles **118**, **120**. The gauge **146**, by quantifying the deflection of the handles **118**, **120** when they are squeezed together, gives an accurate measurement of force applied across the SC device **10**. In the embodiment of the compression device **90** shown in FIG. **20**, gauge **146** includes an arm **148** attached to pivot **130** and located between handles **118**, **120**. The arm **148** preferably has a circular, oval, square or rectangular cross-section and a horizontal and a vertical component **149**, **151**, respectively. The arm **148** has indicia **150** located on at least a portion of the horizontal component **149**.

The gauge **146** has an indicator **152** that is an annular spacer located along the horizontal component **149** of arm **148**. The indicator **152** has a central opening **154** sized to be approximately the same size and shape as the cross-sectional size and shape of the horizontal component **149** of arm **148** so that indicator **152** is attached to the horizontal component **149** by sliding the horizontal component **149** through the first central opening **154**. A frictional fit between the first central opening **154** and the horizontal component **149** holds the indicator **152** in position on the horizontal component **149**.

As mentioned above, when the handles **118**, **120** are squeezed together, the resulting amount of deflection of the handles **118**, **120** is directly related to the force applied by the physician as he or she squeezes the handles **118**, **120** together. Because the vertical component **151** of the arm **148** is rigidly attached to the pivot **130**, as the handles **118**, **120** move together as a result of being squeezed, the horizontal component of the arm **148** and its associate indicator **152** does not move. As a result, the handle **120** will be deflected along the horizontal component **149** of the arm **148** and along the indicia **150** located on the horizontal component **149**. By observing the location of the handle **120** with respect to the indicia **150** on the horizontal component **149**, the amount of force applied to handles **118**, **120** and, therefore to the distal ends **126**, **128** of feet **122**, **124**, is indicated. When the distal ends **126**, **128** are placed in functional contact with the notches **142**, **144** of the male plate **12** and female plate **14**, the gauge **146** indirectly measures the compression being applied to the graft, and allows the surgeon to stop compressing once a predetermined force has been achieved.

By placing the indicator **152** at a desired location on the horizontal component **149** of arm **148**, the physician can squeeze the handles **118**, **120** together until the handle **120** moves into contact with the indicator **152**. At this point, the physician knows that the desired amount of force has been applied to the compression device **90** and thereby to the SC device **10** to the graft.

In another embodiment of the compression device **90** shown in FIG. **22**, gauge **146** again includes an arm **148**. But, in this embodiment, the arm **148** is connected to a rigid arm **156** located on the outside of handle **118**. Rigid arm **156** is attached to handle **118** near the pivot **130**. Arm **148** extends from the rigid arm **156** in the direction that handle **118** moves when it is squeezed together with handle **120** and may extend through a slot in handle **118** or may be formed around handle **118** so that arm **148** extends toward handle **120**. In this embodiment as well, indicator **152** is located between handles **118**, **120**.

As mentioned above, when the handles **118**, **120** are squeezed together, the resulting amount of deflection of the handles **118**, **120** is directly related to the force applied by the physician as he or she squeezes the handles **118**, **120** together. Because the arm **148** is rigidly attached to the rigid arm **156**, as the handle **118**, **120** move together as a result of being squeezed, the arm **148** and its associate indicator **152** does not move. As a result, the handle **118** will be deflected along arm **148** and along the indicia **150** located on arm **148**. By observing the location of the handle **118** with respect to the indicia **150** on arm **148**, the amount of force applied to handles **118**, **120** and, therefore to the distal ends **126**, **128** of feet **122**, **124**, is indicated. When the distal ends **126**, **128** are placed in functional contact with the notches **142**. **144** of the male plate **12** and female plate **14**, the gauge **146** indirectly measures the compression being applied to the graft, and allows the surgeon to stop compressing once a predetermined force has been achieved. Again, by observing the location of the handle **118** versus the indictor, the surgeon will know that the desired amount of force has been applied to the compression device **90** and thereby to the SC device **10** to the graft.

An alternative embodiment of the compression device **90** is referred to as the static compensating compressor **590** and shown in FIGS. **24-27**. The static compensating compressor **590** utilizes a force indicator **592** and a method to measure static compressive forces applied by the patient's own anatomy to allow the surgeon to factor the patient's own static compressive forces out to ensure the correct value of the absolute compression applied through the SC device **10** to the vertebral bodies. The static compensating compressor **590** includes a turnbuckle **594** that uses a threaded nut **596**, threaded inserts **598**, along with a series of compression springs **600** and guide rods **602**, collectively known as the distraction mechanism **604**, to allow the surgeon to apply a measurable distraction force (a force in the opposite direction to the compressive force) to unload the vertebral segment. By unload, we mean to take compression pressure, usually applied by the patient's own muscles and ligaments, off the vertebral segments. Once compression pressure on the vertebral segment has been unloaded from the vertebral segment, a null point (i.e., a point where there is no compression or distraction force on the vertebral bodies) is established and therapeutically useful compression can be applied to the vertebral segment at a known rate.

The force indicator **592** has a central processing unit (CPU) **606** and a display **608** to determine and indicate the amount of force applied in either compression or distraction to the SC device **10** and a zeroing function that allows the surgeon to compensate for static anatomical compression. The force indicator **592** also includes a strain gauge **610**. The force indicator **592** is a simple electronic device that measures the resistance across the strain gauge **610** that is secured to one of the arms **114**, **116** of the compressor **90** and then uses the CPU **606** to determine, by formula or through a lookup table, and indicate the amount of force applied by the compressor **90** and then indicate this amount of force on the display **608**. The CPU **606** may be an application specific integrated circuit (ASIC), a digitally based central processing unit or discrete components.

The display **608** is preferably attached to one of the handles **118**, **120** of the arms **114**, **116** and the CPU **606** and the display **608** are preferably combined into a single unit. However, either or both the CPU **606** and the display **608** may be

located remotely from the static compensating compressor **590** and the CPU **606** and the display **608** may be located separately from each other.

The strain gauge **610** is preferably located on a distal end **126**, **128** of a respective arm **114**, **116** of the compression device **90** although the strain gauge may be located anywhere on an arm **114**, **116** or on the pivot **130**. As the physician applies compression through the compression device **90** to the SC device **10** and thus to the vertebral bodies by squeezing the handles **118**, **120** of the compression device **90** together, the distal ends **126**, **128** will flex or bend slightly. The strain gauge **610** measures this flexing or bending of the distal ends **126**, **128** and communicates the value to the CPU **606** where the force value, once determined, indicates the amount of force applied to the SC device **10**, and thus to the vertebral bodies, as is well understood in the art.

As mentioned above, the static compensating compressor **590** is able to apply distraction pressure to the vertebral bodies through the use of a turnbuckle **594** (FIG. **26**). The threaded nut **596** has a pair of threaded holes **612**. The threaded holes **612** are threaded in opposite directions (i.e., with right and left handed threads) as is well understood in turnbuckles. The threaded inserts **598** each have a threaded end **614** and a non-threaded end **616** to which a guide rod **602** is attached. The guide rods **602** are preferably attached to the non-threaded ends **616** through springs **600** that have a low spring force. Springs **600**, when used, apply a low biasing force to the turnbuckle **594** to remove looseness in the connection between the turnbuckle **594** and the arms **114**, **116**. In another embodiment, the guide rods **602** may be attached directly to the non-threaded ends **616**. The threaded inserts **598** are also each threaded on their threaded ends **614** in opposite directions (i.e., with right and left handed threads) and are mated with the threaded holes **612** of the threaded nut **596** so that as the threaded nut **596** is rotated in a first direction, the threaded inserts **598** are drawn into the threaded holes **612** and as the threaded nut **596** is rotated in a second direction, the threaded inserts **598** are moved out of the threaded holes **612**. As a result, as the threaded nut **596** is rotated in a first direction, the turnbuckle **594** expands in length and as the turnbuckle **594** is rotated in a second direction opposite the first direction, the turnbuckle contracts in length.

The turnbuckle **594** is preferably attached between and applies a preload to the handles **118**, **120** of the arms **114**, **166** of the compressor **90**. However, the turnbuckle **594** may also be attached between and apply a preload to the distal ends **126**, **128** of the arms **114**, **166** of the compressor **90**. In either embodiment, the turnbuckle **594** is fitted between the arms **114**, **116**, either between the handles **118**, **120** or distal ends **126**, **128** preferably in slots **618**, secured with pins **620** or other suitable retaining devices well understood in the art. In a variant of this embodiment, the pins **620** could be quick release pins, allowing the turnbuckle **594** to be quickly removed once the null point is found, as explained below, so that the compressor **90** would be used thereafter without the turnbuckle **594**.

Once the turnbuckle **594** is attached to the arms **114**, **116**, by turning the threaded nut **596**, the turnbuckle **594** expands or contracts (depending on the direction the threaded nut **596** is rotated) thereby applying a preload in either a compression or distraction direction to the arms **114**, **166** of the compressor **90** and thus to the SC device **10** and ultimately to the vertebral bodies. This preload allows the vertebral segment that the SC device **10** is spanning to become unloaded or lifted. By "lifted" or "lift-off" we mean that a distraction force has been applied to the vertebral segment by the compressor **90** and SC device **10** to the point where the distraction force is equal to the anatomical compression force applied to the vertebral segment by the patient's own muscles and ligaments. At this point, called the null point, there is a net zero force applied to the affected vertebral segment so that the affected vertebral bodies separate or "lift-off" of each other slightly which separation is visually ascertained by the physician.

Once lift-off has been determined, and consequently, the null point established, a button is pushed on the display **608**, on the CPU **606** itself or otherwise, including remotely, to alert the CPU **606** that strain measured by the strain gauge **610** at that point is the null point. As a result, the CPU **606** directs the display **608** to indicate a zero reading at that point.

At this point, the turnbuckle **594** is preferably removed from the compressor **90**. As the turnbuckle **594** is removed, the patient's anatomical compression force will be applied to the affected vertebral segment. This compression force will be transferred through the SC device **10** to the compressor **90** where the strain gauge **610** will measure the anatomically applied compression force and the CPU **606** will direct the display **608** to indicate the anatomically applied compression force. Thereafter, the surgeon applies an additional compressive force to the SC device **10** which additional compressive force will be sensed by the strain gauge **610** combined with the compressive force applied by the patient's own anatomy. As a result, the CPU **606** will determine the total compressive force applied to the vertebral segment (i.e., the summation of the patient's own anatomical compressive force and the compressive force being applied by the physician by the compressor **90**) which total compressive force is displayed on the display **608**. The physician then applies the additional compressive force to the vertebral segment until a desired total compressive force for maximum therapeutic value is obtained.

If the force indicator **592** is set to a null point before distraction pressure is applied to the vertebral segment by the turnbuckle **594**, the force indicator **592** will also indicate the distraction pressure applied to the vertebral segment by the turnbuckle **594**. At the point where lift-off occurs, the display **608** will indicate the amount of distraction pressure being applied by the turnbuckle **594** which equals the amount of compression force that is applied by the patient's own anatomy. This amount of compression force is also potentially valuable information in that the amount of compression force anatomically applied by the patient may be used by the physician to determine the overall health and strength of the patient's inherent anatomical compression mechanism. Thereafter, the physician may set the force indicator **592** to zero as described above to indicate the null point for the application of compression force also as described above.

In a variant to the embodiments of the compression device **90** described above, a small cannula **158** is attached to the compression device **90** at the pivot **130**. The cannula **158** is directed downward toward the SC device **10**. This cannula **158** is intended to receive a special screwdriver **160** that activates the locking mechanism **88** of the SC device **10** when the desired compression is achieved. The screwdriver **160** is inserted through the cannula **158** into the loosened locking mechanism **88** as the compression device **90** engages the male plate **12** and female plate **14**. Thus, it is possible for the surgeon to maintain compression across the graft with one hand on the compression device **90**, to determine the degree of compression achieved on the SC device **10** by visualizing the compression gauge **146**, and to activate the locking mechanism **88** of the SC device **10** with the other hand,

causing the SC device **10** to become a rigid construct and preventing further movement of the vertebral bodies from occurring.

Alternately, the physician may use the screwdriver **160** without inserting it through the cannula **158** or may use the screwdriver **160** in an embodiment of the compression device **90** that does not include a cannula **158**. Further, in any of the embodiments of the compressor **90**, the compressor **90** may be disposable or reusable.

One mechanism of fixing the bone screws **43** to the male plate **12** at a rigid predetermined angle is described as follows. As mentioned above, bone screws **43** fix the male plate **12**, the female plate **14** and the interconnecting plate, **15**, if present, to the vertebral bodies. The bone screws **43** may be machined, as is common for such screws, with two separate sets of threads, one on the shaft of the screw **43**, the second set on the head of the screw **43**. These threads are distinct from each other in that they have different pitches and distinct outer diameters. The pitch and outer diameter of the threads on the shaft of the screw **43** are that of a standard cancellous bone screw. In order to engage the main male plate **12**, the diameter of the head **45** of the bone screw **43** head is significantly larger than the diameter of the threads on the shaft of the bone screw **43**. However, the threads on the bone screw **43** are smaller in outer diameter and tighter in pitch than the bore of the screw receiving holes **38**. These threads are machined to engage threads of similar pitch and diameter in the screw receiving holes **38** of the male plate **12**.

The screw receiving holes **38** are machined to project the screw **43** into the vertebral body at a predetermined angle determined to be most advantageous for fixing the SC device **10** to the vertebral bodies. Thus, by engaging the threads on the head **45** of the screw **43** with those in the screw receiving hole **38**, the screw **43** projects into the vertebral body at the predetermined angle and maintains a rigid fixed relationship with the male plate **12**.

The interaction between the bone screws **43** and the SC device **10** described above is one of the many ways that bone screws **43** can be connected to the SC device **10**. However, it is well understood in the art that there are other commercially available ways to connect devices like the SC device **10** to vertebrae that could also be used. As a result, it is intended that any method of connecting the SC device **10** to vertebral bone so that there is a rigid fixed relationship between the SC device **10** and the bone may be used with the SC device **10** of the present invention.

The mechanism of fixing the screws **43** to the female plate **14** at a rigid predetermined angle is similar to the mechanism for fixing the screws **43** to the male plate **12** at a rigid predetermined angle as described above. Again, the bone screws **43** are machined, as is common for such screws, with two separate sets of threads, one on the shaft of the screw **43**, the second set on the head of the screw **43**. These threads are distinct from each other in that they have different pitches and distinct outer diameters. The pitch and outer diameter of the threads on the shaft of the screw **43** are that of a standard cancellous bone screw. In order to engage the female plate **14**, the inner diameter of the screw head **45** is significantly larger than the inner diameter of the threads on the shaft. However, the threads on the screw head **45** are smaller in outer diameter and tighter in pitch than the bore of the screw receiving holes **82**. These threads are machined to engage threads of similar pitch and diameter in the screw receiving holes **82** of the female plate **14**. The screw receiving holes **82** are machined to project the screw **43** into the vertebral body at a predetermined angle. Thus, by engaging the threads on the head **45** of the screw **43** with those in the screw receiving holes **82**, the screw **43** projects into the vertebral body at the predetermined angle and maintains a rigid fixed relationship with the female plate **14**.

The SC device **10** as described in the embodiment above has the option of using fixed angle screws. However, variable angle screws **43** may be used with the SCD device **10** as long as when these screws **43** are placed through the male plate **12**, female plate **14** or interconnecting plate **15** into bone, their relationship with the respective plate **12**, **14** or **15** becomes rigid. There are numerous methods of attaching bone screws to plates well understood in the art, all of which may be used with this device. It is important that the relationship between the screws and the plates **12**, **14**, **15** becomes rigid once the screws are placed in order to avoid "toggle" of the screws during the compression maneuver. "Toggle" must be avoided, because if it occurs, actual compression may be significantly less than measured.

Most currently available non-adjustable plates have the option to place screws into the bone at a variety of different angles to obtain optimum purchase. While this is necessary to position static plates, it is not necessary in the SC device **10**. In fact the sliding capability that the SC device **10** has in the unlocked arrangement renders the common use of variable screws superfluous. Nevertheless, any type of screw may be used with the SC device **10** as long as a mechanism exists for rigidly fixing the screw to the plate.

The importance of having screws **43** that are rigidly fixed to the male plate **12** and female plate **14** at a predetermined angle is that compression occurs through the entire SC device **10** (the sliding components of the SC device **10** (male plate **12** and female plate **14** and the two rigidly attached screws), rather than through the screws individually. Also, as mentioned, the bottom side **36** of the male plate **12** and the bottom side **54** of the female plate **14**, and of the interconnecting plate **15** if present, are roughened, allowing the SC device **10** to "grip" the vertebral body. These characteristics in combination provide for a much larger surface area to compress against (the contact of the bottom side **36** and bottom side **54** on the anterior surface of the vertebrae as well as the two rigidly fixed bone screws in the male plate **12** and female plate **14**, respectively). This results in a much more even compression against the entirety of the interbody graft and minimizes the potential for screw cutout or bony failure.

For purposes of illustrating the operation of locking mechanism **88** of the invention in the embodiment shown in FIGS. **1-14**, a variant of the embodiment described above will be used. In this variant, shown in FIGS. **15-17**, there is no interconnecting plate **15**. Instead, the male plate **12** and female plate **14** intermesh directly through the interaction of the central protrusion **28** and side protrusions **29** of the male plate **12** and the left and right guides **58**, **60** of the female plate **14**. In describing the operation of the SC device **10**, it is to be understood that the concepts described apply as well to the interaction between the male plate **12** and one end of the interconnecting plate **15** and the interaction between the opposite end of the interconnecting plate **15** and the female plate **14**.

In use, the central protrusion **28** is inserted into the protrusion receiving channel **56** (FIG. **15**). Because protrusion receiving channel **56** is dimensioned to receive central protrusion **28** with the locking clamp **16** in place, central protrusion **28** is precisely located and retained within the protrusion receiving channel **56**. In this position with the locking clamp **16** in place on the top surface **30** of central protrusion **28**, the ridges **46** and valleys **48** on the parallel sides **96** of locking clamp **16** come into loose contact with the inner surface **61** of left guide **58** and right guide **60** of the female plate **14**. (FIG.

15) The locking screw **18** is passed through the screw hole **93** so that its distal end **110** comes into contact with and is threaded into the threaded hole **35** a sufficient amount to locate the distal end **110** of the locking screw **18** in the threaded hole **35** but not a sufficient amount to deform the locking clamp **16**.

Bone screws are passed through the screw receiving holes **38** and **82** and into the vertebral bone. These bone screws are screwed into the vertebral bone until the heads of the bone screws seat into the basins **40**, **84** of the male plate **12** and female plate **14**, respectively.

The compression device **90** is then used to apply the desired compression to the SC device **10**. The pins **132** are placed in the notches **142**, **144** and the handles **118**, **120** are squeezed together. As a result, compression pressure is applied to the male plate **12**, female plate **14** and interconnecting plate **15** if present, and thereby to the vertebral bone through the bone screws.

As mentioned above, where a gauge **146** is present, the amount of compressive force applied to the device **10** can be ascertained.

As shown in FIGS. **16** and **17**, when the male plate **12** is moved into an intermeshing position with the female plate **14** and the appropriate amount of compression is applied to the SC device **10** through the compression device **90**, the screwdriver **160** is coupled to the head **106** of the locking screw **18**. The screwdriver **160** is rotated so that the threaded body **108** of locking screw **18** is threaded into the threaded hole **35**. The locking screw **18** is then screwed further onto the central protrusion **28** on the male plate **12** so that the head **106** contacts the top surface **92** of the locking clamp **16**.

Once the head **106** has contacted the top surface **92**, further rotation of the locking screw **18** will cause the head to be forced into the material of the top surface **92** of the locking clamp **16**. This will cause the locking clamp **16** to interfere so that the parallel sides **96** will be forced into engaging and locking contact with the inner surfaces **61** of the left and right guides **58**, **60** on the female plate **14** or the interconnecting plate **15**. This outward compression from the interference fit is transferred through the left and right guides **58**, **60** to cause engaging and locking contact between the outer surface **63** of the left and right guides **58**, **60** and the inner surface **37** of the side protrusions **29**. The interaction between the head **106** and the screw hole **35** locks the locking clamp **16** against the right and left guides **58**, **60**. Once male plate **12** is secured with respect to the female plate **14**, the compression device **90** is removed. As a result, the compression applied to the SC device **10** through the compression device **90** will be locked to the vertebral bone through the male plate **12** and female plate **14** (and interconnecting plate **15** if used) because these various components are locked in a fixed relationship to each other.

An alternate embodiment of the locking mechanism **88** is shown in FIGS. **28-32** and is described as follows. In this embodiment there is no locking clamp **16** and the locking screw **18** (FIG. **30**) is large in diameter and is tapered from the head **106** to the distal end **110** so that the diameter of the head **106** is significantly larger than the diameter of the distal end **110**. In addition, the diameter of head **106** of the locking screw **18** is greater than the width of the central protrusion **28**. Further, the threaded hole **35** of the central protrusion **28** of the male plate **12** is fashioned in a threaded tapered fashion so that the locking screw **18** fits into the threaded hole **35**. In this embodiment the central protrusion **28** may include a slot **41** through which the threaded hole **35** passes to allow maximal deformation of the central protrusion **28** along the length of the central protrusion **28**.

Thus, when appropriate compression has been applied to the vertebral bodies by the SC device **10**, the locking mechanism **88** is engaged by advancing the locking screw **18** into the threaded hole **35**. The advancement of the locking screw **18** into the threaded hole **35** deforms the outer aspect of the central protrusion **28** which surrounds the threaded hole **35** thereby causing this portion of the central protrusion **28** to expand and interfere with the inner surface **61** of left guide **58** and right guide **60** of the female plate **14**. The presence of the slot **41** helps the deformation of the outer aspects of the central protrusion **28** by making it easier for the two sides of the central protrusion **28** to move away from the threaded hole **35** under the influence of the locking screw **18**. This outward compression from the interference between expanded central protrusion **28** and left and right guides **58**, **60** is transferred through the left and right guides **58**, **60** to cause engaging and locking contact between the outer surfaces **63** of the left and right guides **58**, **60** and the inner surface **37** of the side protrusions **29**.

It should be noted that the SC device **10** is a modular and expandable device. The characteristics of this device allow it to be disassembled in vivo and expanded to immobilize adjacent vertebral segments (or other bone pieces or segments) by the insertion of one or more interconnecting plates **15** to form an interconnecting span as described above.

Thus, should subsequent surgery be required, as for example, in the case of adjacent segment disease (the segment adjacent to a fused segment undergoing accelerated degeneration), it is not necessary to expose the entirety of the SC device **10** and remove it to extend the fusion to the adjacent segment (as is the case with nearly all current plates). Instead, an end portion of the SC device **10** (e.g., either the male plate **12** or female plate **14**) may be removed (leaving the remainder of the SC device **10** intact), the fusion completed and the SC device **10** simply expanded to include the newly fused segment by inserting one or more interconnecting plate **15**, then reapplying the end portion (either the male plate **12** or female plate **14**, respectively) of the SC device **10** to the newly fused vertebrae, applying compression as explained herein and locking and securing the SC device **10**.

An alternate embodiment of the SC device **10** is shown in FIGS. **33-35**. In this embodiment, the locking screw **18** of the locking mechanism **88** is modified to include a cam **162** that rotates around the locking screw **18** below the head **106** (FIG. **35**). Further, the edges of channel **80** form a track **164** (FIG. **34**) dimensioned to receive and constrain the cam **162** within the track **164** in a relatively conformal manner. In addition, in this embodiment of the locking mechanism **88**, there is no locking clamp **16** and the central protrusion **28** does not have the protrusion ridges **50**.

Cam **162** is relatively disk shaped with elongated opposed outer edges **166**. The outer edges **166** resemble somewhat a "V" with the bottom of the V being farther from the body **108** than the open mouth of the V which rotates around the body **108** of locking screw **18**. The locking screw **18** in this embodiment rotates freely with respect to cam **162**. However, the cam portion can be rotated into contact with and engage the track **164** when rotated 90 degrees about the body **108**. When the locking screw **18** is in the unlocked position, the male plate **12** is inserted into the protrusion receiving channel **56**. With the cam **162** rotated so that the cam **162** does not contact the track **164**, the cam **162** and the locking screw **18** move easily into the channel **80**. Then the male plate **12** and the female plate **14** are moved to the desired position relative to each other, the cam **162** is rotated 90 degrees so that the cam **162** contacts the wall of the track **164** where such frictional contact prevents the male plate **12** from moving relative to the female plate **14**.

In addition, though both the locking screw **18** and the female plate **14**, including the track **164** are preferably made of titanium, the locking screw **18** is of a significantly harder grade. In this way, as the locking screw **18** is rotated 90 degrees, because the cam **162** is present and has a cam shape, the cam **162** is forced into the track **164**, effectively deforming the cam **162** and forming a "cold weld" with the track **164**. In this way, a rigid, permanent fixation between the locking screw **18** and the male plate **12** to which it is attached and the female plate **14** through track **164** is achieved and compression is maintained. The SC device **10** in this embodiment is also designed to work with the compression device **90**.

An alternate embodiment of the SC device **10** in a preferred embodiment shown in FIGS. **36-54** also has a male plate **12** and a female plate **14**. In addition, the SC device **10** in this embodiment also has a locking plate **316** and a locking screw **318** that, in combination with standard cancellous bone screws (not shown) fix the SC device **10** to the patient's vertebrae. This SC device **10** has a top side **320**, a bottom side **322** and opposed medial sides **324**.

The male plate **12** has a male main body **326** and a protrusion **328** extending away from the male main body **326**. The protrusion **328** has a top surface **330** and a longitudinal axis **332**. The male main body **326** is relatively flat with a top side **334** and a bottom side **336** and, in a preferred embodiment, has two screw receiving holes **338**. The screw receiving holes **338** each have a bowl-shaped basin **340** on the top side **334** to receive the heads of the screws and a throughhole **342** through which the main body of the screws pass to come into contact with the vertebral body. The throughholes **342** are machined to have a rigid relationship with the bone screws as will be described hereafter.

The bottom side **336** of male plate **12** is preferably roughened, thereby allowing the bottom side **336** of male plate **12** to "grip" the vertebral body when the bottom side **336** is brought into contact with and is secured to the vertebral body by the interaction of the screws and the male main body **326** as described above.

As mentioned, the male plate **12** has a protrusion **328** with a top surface **330** and a longitudinal axis **332**. Protrusion **328** is dimensioned to mate with and secure the male plate **12** with the female plate **14** as will be described in detail hereafter. The length of protrusion **328** along the longitudinal axis **332** is chosen to be slightly longer than the distance the SC device **10** is intended to provide compression over.

Protrusion **328** has a slot **344** extending entirely through it approximately perpendicular to the top surface **330**. Protrusion **328** also has a series of alternating ridges **346** and valleys **348**, collectively protrusion ridges **350**, located on a portion of its top surface **330**. Ridges **350** are preferable angled slightly with respect to the longitudinal axis **332** for a purpose to be explained hereafter.

The female plate **14** has a female main body **352** with a bottom side **354** and a protrusion receiving channel **356**. Protrusion receiving channel **356** is comprised of a left channel **358**, a right channel **360** and a connecting piece **362**. Left channel **358** is basically "C" shaped with a top piece **370**, bottom piece **372** and an outer piece **374**. Although left channel **358** has been described as having a top piece **370**, bottom piece **372** and outer piece **374**, left channel **358** is preferable a single contiguous piece although it could be made of these separate segments connected together.

Right channel **360** has a top piece **370**, a bottom piece **372** and an outer piece **374**. Although right channel **360** has been described as having a top piece **370**, bottom piece **372** and outer piece **374**, right channel **360**, like left channel **358**, is preferably a single contiguous piece although it could be made of these separate segments connected together.

Connecting piece **362** connects the left channel **358** to the right channel **360** at the respective bottom pieces **372**. In the preferred embodiment, connecting piece **362** is integrally formed with the bottom pieces **372** although it could be made of these separate segments connected together. Connecting piece **362** has a threaded hole **376** that extends into connecting piece **362**.

Protrusion receiving channel **356** is dimensioned to snugly receive the protrusion **328** so that the protrusion **328** is "captured" and held in the protrusion receiving channel **356** by relatively conformal physical contact between the outer surface of the protrusion **328** and the inner surfaces of the left channel **358**, right channel **360** and connecting piece **362**.

The female main body **352** also has an upper surface **378** and a channel **380** formed in the upper surface **378** between the left channel **358** and the right channel **360**. Channel **380** extends entirely through the upper surface **378**.

The female plate **14**, also in a preferred embodiment, has two screw receiving holes **382**. These screw receiving holes **382** receive standard cancellous bone screws (not shown) that are threaded into the bone of the vertebrae. In similar fashion to screw receiving holes **338**, the screw receiving holes **382** also have a bowl-shaped basin **384** on the upper surface **378** to receive the heads of the bone screws and a throughhole **386** through which the main body of the bone screws pass to come into contact with the vertebral body. The throughholes **386** are machined to provide a rigid relationship with the bone screws. The SC device **10** has a locking mechanism **388**. The locking mechanism **388** includes locking plate **316** and locking screw **318** as well as the ridges **346** and valleys **348** on the top surface **330** of protrusion **328** of the male plate **12** and the threaded hole **376** and channel **380** of female plate **14** as described below. Locking mechanism **388** converts "active" compression applied by the surgeon using the compression device **90** described above interacting with the SC device **10** at the time of surgery to "static" compression after surgery. The locking mechanism **388** also provides rigid fixation to the SC device **10** to optimize bone healing and preventing further settling from occurring.

The locking plate **316** has a top surface **392**, a bottom surface **394** and parallel sides **396**. The bottom surface of locking plate **316** preferably has a series of ridges **398** and valleys **400**, collectively locking ridges **402**, of similar dimensions to the ridges **346** and valleys **348** of the protrusion **328** to locate and affix the locking plate **316** to the protrusion **328** as will be described hereafter. In a most preferred embodiment of the invention, the ridges **346** and valleys **348** of the protrusion **328** and the ridges **398** and valleys **400** of the locking plate **316** are angled slightly with respect to the longitudinal axis **332**. Through this configuration, the ridges **398** and valleys **400** of the bottom surface **394** of the locking plate **316** preferably contact and engage with the ridges **346** and valleys **348** of the protrusion **328** in frictional or mechanical contact to precisely locate and affix the locking plate **316** to the protrusion **328**. Further, as shown in FIGS. **42** and **48-53**, because the protrusion ridges **350** and the locking ridges **402** are angled, as the locking plate **316** is moved from one side of the channel **380** to the other, as the locking ridges **402** seat with the protrusion ridges **350**, the male plate **12** is moved into compression with the female plate **14**. This compression is transferred through the male plate **12** and female plate **14** to the vertebral bone.

The width of the locking plate **316** (i.e, the distance between the parallel sides **396**) is such that the locking plate **316** will fit snugly into the channel **380** formed in the upper

surface **378** of the female plate **14** of the SC device **10** but still allow the locking plate **316** to move in a direction perpendicular to the parallel sides **396** within the channel **380**.

Locking plate **316** has a slot **404**. Slot **404** is aligned with channel **344** of the protrusion **328** and allows a locking screw **318**, as explained hereafter, to pass through both the slot **404** and mate with the treaded hole **376** as described hereafter. Slot **404** is also dimensioned to conformally mate with the head **406** of screw **318** so that contact between the head **406** and slot **404** as the locking screw **318** is threaded into threaded hole **376** moves the locking ridges **402** into contact with the protrusion ridges **350**.

A single large locking screw **318**, is dimensioned to rotate freely within the slot **404** of the locking plate **316** activates the locking mechanism **388**. In the embodiment of the invention shown in FIGS. **36-54**, the locking screw **318** has a head **406**, a threaded body **408** and a distal end **410** where the head **406** has a larger cross-sectional diameter than the threaded body **408**.

In use, the protrusion **328** is inserted into the protrusion receiving channel **356** (FIGS. **39** and **48**). Because protrusion receiving channel **356** is dimensioned to conformally receive protrusion **328**, protrusion is precisely located and retained within the protrusion receiving channel **356**. Locking plate **316** is placed on the top surface **330** of protrusion **328** within the channel **380** so that the protrusion ridges **350** come into contact with the locking ridges **402** (FIG. **49**). The locking screw **318** is passed through the slot **404** so that its distal end **410** comes into contact with and is threaded into the threaded hole **376** a sufficient amount to locate the distal end **410** of the locking screw **318** in the threaded hole **376** but not a sufficient amount to secure the locking ridges **402** of the locking plate **316** into secure contact with the protrusion ridges **350** (FIGS. **50-51**).

Bone screws are passed through the screw receiving holes **338** and **376** and into the vertebral bone. These bone screws are screwed into the vertebral bone until the heads of the bone screws seat into the basins **334**, **378** of the male plate **12** and female plate **14**, respectively.

The compression device **90** is then used to apply the desired compression to the SC device **10**. The pins **132** are placed in the notches **442**, **444** and the handles **118**, **120** are squeezed together. As a result, compression pressure is applied to the male plate **12** and female plate **14** and thereby to the vertebral bone through the bone screws. As mentioned above, where a gauge **146** is present, the amount of compressive force applied to the SC device **10** can be ascertained. Once the desired amount of compressive force is applied to the SC device **10**, the screwdriver **160** is coupled to the head **406** of the locking screw **318**. The screwdriver **160** is rotated so that the threaded body **408** of locking screw **318** is threaded into the threaded hole **376**. In this process, the locking ridges **402** are brought into secure contact with the protrusion ridges **350**. But, to secure an optimum fit between the locking ridges **402** and the protrusion ridges **350**, it may be necessary to move the locking plate **316** from side to side within the channel **380** until they mate optimally and impart a compression on the male plate **12** and female plate **14** (FIG. **52**). Once this optimal mating occurs, the screwdriver **160** is rotated further. The interaction between the head **406** and the slot **404** locks the locking plate **316** against the protrusion **328**. Locking screw **318** is tightened into the threaded hole **376** so that the male plate **12** is securely positioned with respect to the female plate **14**. Once male plate **12** is secured with respect to the female plate **14**, the compression device **90** is removed.

Another alternate embodiment of the SC device **10** is shown in FIGS. **55-56**. In this embodiment, the SC device **10** is as described above except that the SC device **10** has a spring mechanism **168** integral between the ends of the male plate **12** and female plate **14** that provides a near constant force applied to a fixed vertebral segment (or segments) through a standard buttressing or tension band construct. Spring mechanism **168** has three parts, a relatively flat spring plate **170**, guide pins **184**, **186** and a guide plate **172**. Spring plate **170** has ends suitable for attaching to bone via one or more bone screws.

Spring **178** is preferably a plurality of flexible members that resist being moved in a lateral direction, in this case, in the direction of moving the one plate end **174** away from the other plate end **176**. In a preferred version of this embodiment, the spring **178** is a plurality of flat serpentine shaped members made of a spring metal such as spring steel. However, the spring **178** could also be made of a single member that has spring-like attributes and could be made of materials other than metal so long as the elements of spring **178** possess the ability to resist stretching according to a linear restoring force (i.e., follows Hooke's law).

Guide plate **172** reinforces spring plate **170** and provides over extension protection as well as flexion/extension moment buffering. Over extension protection is provided by guide pins **184**, **186** attached to spring plate **12** via slots and limit the extension of the spring **178**. Flexion/extension is controlled by the guide plate **172** in close contact with the spring plate **12**.

This embodiment of SC device **10** allows the SC device **10** to settle into position on the vertebral bone and minimize the deflection of the male plate **12** and the female plate **14** without a drastic reduction in the SC device **10**'s ability to provide a consistent tension force. Further, after the SC device **10** is implanted, the surgeon can determine the actual level of compression by measuring the overall change in length of the construct and applying Hooke's law to determine the relative rate of compression.

Another feature of an embodiment of the invention shown in FIG. **57** is that of a series of trial spacers **202** that include a strain gauge capable of measuring compressive strain through electromagnetic techniques as are well understood in the art. These spacers **202** are preferably cylindrical in shape with a handle which allows them to be inserted between the vertebral bodies. The spacers are machined to have the approximate dimensions of the bone graft which is to be placed between adjacent vertebrae (in the disc space once the disc has been removed). This embodiment also includes a handle **204** attached to the spacer **202** in order to allow the surgeon ease in facilitating insertion and extraction of the spacer **202**. The cylinders of the spacer **202** are preferably machined in height increments (e.g. one millimeter) in order to accommodate a variety of disc space heights.

The spacer **202** serves two purposes. First, it enables the surgeon to "size" the disc space in order to place an appropriate sized graft, in the same manner that many allograft spacers currently have "trials". Second, each spacer **202** has the characteristics of a strain gauge which is able to directly measure the "passive" force applied to that spacer **202** by the adjacent vertebral bodies, once the spacer **202** is inserted. In this way the surgeon may estimate the approximate "passive" force which would be applied to a similar sized bone graft. The total force applied to that graft, then, would be the sum of the passive force applied to the graft (as measured by the spacer of similar dimensions) and the active force applied by the surgeon through the compression device **90**. Thus, by using the strain-gauge spacer **202** in conjunction with the compression device **90**, the surgeon may obtain an accurate assessment of total force applied to the graft. This is beneficial

in that it allows further study of the "optimal" force which must be applied in order to reliably achieve fusion.

In all the embodiments shown, the SC device **10** is a unique device that utilizes Wolff's law to compress two or more adjacent cervical vertebrae while fusion between the vertebrae occurs by allowing static, rigid compression to be applied to interbody graft in the cervical spine. Static, rigid compression has definitively been shown to increase bony union in a long bone fracture model. Lumbar interbody fusions have been shown to heal at a higher rate than intertransverse fusions, presumably because of the constant loading of the graft. No other currently available cervical device allows for active, static compression.

It should be noted that use of the SC device **10** is by no means limited to use in the cervical spine. Any of the aforementioned embodiments, in a somewhat larger version or having a curved bottom side **22** (FIG. **58**) as will be clear to those skilled in the art, may be used for the same or similar purposes in the thoracic or lumbar spine, or in instances where static compression is desired outside of the spine (e.g., and without limitation, bone fractures, as for example, of long bones like the femur or bones of the skull, hip or scapula) (FIG. **59**).

In the thoracic spine a larger version of the SC device **10** may be placed on the side of the thoracic spine (as opposed to the front) in order to facilitate approach to the thoracic spine and to avoid large vascular structures that reside immediately in front of the thoracic spine.

In the lumbar spine, a larger version of the SC device **10** may be placed either on the side of the spine to facilitate exposure and avoid vascular structures or directly on the front of the spine, especially at the lumbosacral junction. It is believed that in order to obtain anterior fusion at L5-S1, it is important to have a fully contoured SC device **10** (FIG. **58**) that is simply comprised of a male plate **12** and a female plate **14** with a curved bottom side **22** matching the curvature of the vertebral segments in the L5-S1 region.

As mentioned above, the SC device **10** may be used to obtain union of fractures, nonunions, osteotomies and other bony defects in regions other than the spine. In the embodiment suited for use with other bones, the SC device **10** should be sized appropriately to the bone and have the option of placing more than two screws **138** on either side of the defect where union is desired (FIG. **59**). The SC device **10** allows for maximum utilization of Wolff's Law to facilitate healing in that reproducible measurable compression is applied in each of these scenarios to obtain bony union.

The SC device **10** described herein has the following four unique characteristics which together provide for static compression of the vertebral body-graft interface:

- The use of fixed-angle screws to secure the SC device **10** to the vertebral bodies;
- The use of a compression device to apply and measure the pressure applied to the vertebral bodies by the SC device **10**;
- The technique of using active, static compression to assist the fusion process; and
- The use of a locking mechanism **88** that maintains compression during the fusion process to facilitate bone growth.

These four characteristics of the SC device **10** are not currently found in any other spinal device. As a result, it is believed that the SC device **10** in any of the disclosed embodiments provides an optimal environment for spinal fusions to consolidate while preventing frequent non-unions and occasional deformities seen with the use of current dynamic plates.

The SC device **10** in several embodiments has been described in detail above. However, it is to be understood that the specific features of the various components may be modified as will occur to those skilled in the art and still fall within the parameters of the invention. For example, the specific cross-sectional shape of the protrusion **28**, left and right guides **58**, **60** and side protrusions **29** may be modified so long as these components interlock with each other as described herein. Further, the shape of the locking clamp **16** may be modified so long as it is able to be deformed to force frictional or mechanical contact between the various components as described above.

Further, the invention has been described as having a protrusion **28** with side protrusions **29** on a male plate **12** or interconnecting plate **15** and a left guide **58** and right guide **60** on a female plate **14** or interconnecting plate **15**. It is clear that the invention could also be practiced with the male plate **12** or interconnecting plate **15** having a single protrusion **28** with the female plate **14** or interconnecting plate **15** still having the left guide **58** and right guide **60**. Also, the SC device **10** could have two or more protrusions **28** on the male plate **12** or interconnecting plate **15** with a corresponding number of protrusion receiving channels **56** to receive these protrusions **28** and a corresponding number of locking clamps **16**.

The present invention has been described in connection with certain embodiments, configurations and relative dimensions. It is to be understood, however, that the description given herein has been given for the purpose of explaining and illustrating the invention and are not intended to limit the scope of the invention. For example, complimentary versions of the mating aspects of the SC device **10** could be formed and still be within the scope of the invention. In addition, it is clear than an almost infinite number of minor variations to the form and function of the disclosed invention could be made and also still be within the scope of the invention. Consequently, it is not intended that the invention be limited to the specific embodiments and variants of the invention disclosed. It is to be further understood that changes and modifications to the descriptions given herein will occur to those skilled in the art. Therefore, the scope of the invention should be limited only by the scope of the claims.

I claim:

1. A device for compressing two or more adjacent vertebrae comprising:

(a) a male plate with a male main body with a bottom side and a central protrusion extending away from the male main body, the male plate having a longitudinal axis, and the central protrusion of the plate having a top surface including a threaded hole in the top surface;

(b) a female plate having a female main body with a bottom side and a protrusion receiving channel adapted to conformally receive the central protrusion, the female plate having a longitudinal axis wherein the longitudinal axis of the male plate is aligned with the longitudinal axis of the female plate when the protrusion receiving channel receives the central protrusion;

(c) a locking mechanism for allowing the male and female plate to move with respect to each other under compression along their common longitudinal axis when the central protrusion is engaged with the protrusion receiving channel until a desired configuration is achieved and thereafter to prevent the male and female plate from moving with respect to each other, the locking mechanism comprising:

(i) a locking clamp including a longitudinal axis generally parallel to the longitudinal axes of the male and female plates, a top surface and an opposed bottom

surface, the locking clamp further including a hole extending between the top surface and the bottom surface, and parallel sides connected to the top surface and bottom surface forming an inner channel between the parallel sides and the bottom surface; and

(ii) a locking screw dimensioned to rotate freely within the hole of the locking clamp, the locking screw having a head, a body and a distal end opposite the head, the head having a larger cross-sectional diameter than the threaded body, the body being threaded at least on the distal end to correspond to the threads of the threaded hole in the central protrusion;

wherein the locking clamp is located over the central protrusion so that the hole in the locking clamp is aligned with the threaded hole in the top surface of the central protrusion,

wherein a distance between the inner walls of the parallel sides is greater than a width of the central protrusion, and a distance between the outer walls of the parallel sides is less than a width of the protrusion receiving channel, at least a portion of the parallel sides being between the central protrusion and the protrusion receiving channel,

wherein the distal end of the locking screw is capable of passing through the hole and into mating contact with the threaded hole in the top surface of the central protrusion, and

wherein the locking screw is rotatable to allow the head to come into contact with the top surface of the locking clamp,

wherein the locking screw is further rotatable to move the head into contact with the locking clamp, and

wherein the parallel sides of the locking clamp are deformable to allow frictional contact between the parallel sides and the protrusion receiving channel.

2. The device of claim **1** wherein:

(a) the male plate further comprises a means for attaching the male plate to a first vertebrae wherein the means for attaching the male plate to a first vertebrae comprises at least one fixed angle bone screw passing through the male plate into the first vertebrae;

(b) the bottom side of the male plate is rough, thereby allowing the bottom side of the male plate to frictionally contact the first vertebrae when the bottom side of the male plate is brought into contact with and is secured to the first vertebrae by the interaction of the bone screw and the male plate;

(c) the female plate further comprises means for attaching the female plate to a second vertebrae wherein the means for attaching the female plate to a second vertebrae comprises at least one fixed angle bone screw passing through the female plate into the second vertebrae; and

(d) the bottom side of the female plate is rough, thereby allowing the bottom side of the female plate to frictionally contact the second vertebrae when the bottom side of the female plate is brought into contact with and is secured to the second vertebrae by the interaction of the bone screw and the female plate.

3. The device of claim **1** wherein the female plate includes a left guide and a right guide that both extend away from the female main body thereby forming the protrusion receiving channel, the left guide and right guide each having an inner surface, an outer surface, a bottom surface and a top surface.

4. The device of claim **3** wherein the portion of the parallel sides of the locking clamp are between the left guide and the right guide in the protrusion receiving channel.

5. The device of claim **1** wherein the parallel sides of the locking clamp have a series of ridges and valleys along the outer walls.

6. The device of claim **5** wherein the series of ridges and valleys align substantially perpendicular to the longitudinal axis of the locking clamp.

7. The device of claim **1** wherein the locking clamp comprises a material that is harder than the material of the female plate.

8. The device of claim **3** wherein the left guide and right guide are each substantially rectangular in cross-section and have respective inner surfaces and outer surfaces.

9. The device of claim **8** wherein the inner surfaces of the left guide and right guide are substantially planar.

10. The device of claim **8** wherein the outer surfaces of the left guide and right guide are substantially outwardly curved.

11. The device of claim **10** wherein the outer surfaces of the left guide and right guide have a series of ridges extending along at least a portion of the outer surface of the left guide and right guide.

12. The device of claim **3** wherein:

(a) the central protrusion has a boss extending entirely through the central protrusion approximately parallel to the top surface of the central protrusion;

(b) the bottom surface of the left and right guides facing the protrusion receiving channel has a relief cut dimensioned to accept the boss on the central protrusion.

13. The device of claim **3** wherein the male plate further includes a pair of side protrusions extending away from the male main body on opposite sides of the central protrusion, each of the side protrusions having an inner surface and an outer surface, the inner surfaces of the side protrusions directed toward the central protrusion and formed to conformally mate with the outer surfaces of the left guide and right guide of the female plate.

14. The device of claim **1** further comprising one or more interconnecting plates disposed between the male plate and the female plate thereby forming an interconnecting span made up of the one or more interconnecting plates, the interconnecting span having a first end and a second end and being adapted to be securely connected to the female plate at the first end and to the male plate at the second end, to allow the device to be secured to three or more adjacent vertebrae and allow the device to apply pressure to at least the first, second and third vertebrae to facilitate healing of the vertebrae.

15. The device of claim **14** wherein:

(a) the interconnecting span has a single interconnecting plate having a main body, a longitudinal axis, a bottom side, a first end and a second end;

(b) the first end of the interconnecting plate has an interconnecting central protrusion extending away from the interconnecting plate main body and being adapted to conformally fit with the protrusion receiving channel of the female plate;

(c) the second end of the interconnecting plate has an interconnecting plate protrusion receiving channel adapted to conformally receive the central protrusion of the male plate; and

(d) the longitudinal axes of the male plate, interconnecting plate and female plate are aligned when the interconnecting plate protrusion receiving channel receives the central protrusion and the protrusion receiving channel receives the interconnecting central protrusion.

16. The device of claim **15** wherein the interconnecting plate includes means for attaching the interconnecting plate

to the second vertebrae, wherein the male plate attaches to the first vertebrae and the female plate attaches to the third vertebrae.

17. The device of claim **16** wherein the means for attaching the interconnecting plate to the second vertebrae comprises at least one fixed angle bone screw passing through the interconnecting plate into the second vertebrae.

18. The device of claim **17** wherein the bottom side of the interconnecting plate is rough, thereby allowing the bottom side of the interconnecting plate to frictionally contact the second vertebrae when the bottom side of the interconnecting plate is brought into contact with and is secured to the second vertebrae by the interaction of the bone screw and the interconnecting plate.

19. The device of claim **14** wherein:

(a) the interconnecting span has at least a first and a second interconnecting plate, each interconnecting plate having a main body, a longitudinal axis, a bottom side, a first end and a second end;

(b) the first end of the first interconnecting plate having an interconnecting central protrusion extending away from the interconnecting plate main body of the first interconnecting plate and being adapted to conformally fit with the protrusion receiving channel of the female plate;

(c) the second end of the first interconnecting plate having an interconnecting plate protrusion receiving channel adapted to conformally receive the central protrusion of the second interconnecting plate;

(d) the first end of the second interconnecting plate having an interconnecting central protrusion extending away from the interconnecting plate main body of the second interconnecting plate and being adapted to conformally fit with the protrusion receiving channel of the first interconnecting plate;

(e) the second end of the second interconnecting plate having an interconnecting plate protrusion receiving channel adapted to conformally receive the central protrusion of the male plate; and

(f) the longitudinal axes of the male plate, first and second interconnecting plates and female plate are aligned when the second interconnecting plate protrusion receiving channel receives the central protrusion from the male plate and the protrusion receiving channel of the first interconnecting plate receives the central protrusion of the second interconnecting plate and the protrusion receiving channel of the female plate receives the central protrusion of the first interconnecting plate.

20. The device of claim **14** wherein:

(a) the interconnecting span has at series of interconnecting plates, each interconnecting plate having a main body, a longitudinal axis, a bottom side, a first end and a second end;

(b) the first end of each interconnecting plate has an interconnecting central protrusion extending away from the interconnecting plate main body and being adapted to conformally fit with the protrusion receiving channel of an adjoining interconnecting plate or the female plate;

(c) the second end of each interconnecting plate has an interconnecting plate protrusion receiving channel adapted to conformally receive the central protrusion of an adjoining interconnecting plate or the male plate;

(d) the interconnecting span comprises the interconnecting central protrusion of one interconnecting plate being within the protrusion receiving channel of an adjacent interconnecting plate; and

(e) the longitudinal axes of the male plate, interconnecting span and female plate are aligned when the interconnecting plate protrusion receiving channel at the end of the interconnecting span receives the central protrusion from the male plate and the protrusion receiving channel at female plate receives the central protrusion of the opposite end of the interconnecting span.

21. The device of claim **6** wherein the series of ridges are tapered in a direction of alignment.

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